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DRAFT ENVIRONMENTAL IMPACT STATEMENT ON

COLSTRIP ELECTRIC GENERATING UNITS 3 & 4, 500 KILOVOLT TRANSMISSION LINES & ASSOCIATED FACILITIES

VOLUME THREE-B POWER PLANT

ENERGY PLANNING DIVISION, MONTANA STATE DEPARTMENT
OF NATURAL RESOURCES AND CONSERVATION

HELENA, MONTANA 59601

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DRAFT ENVIRONMENTAL IMPACT STATEMENT ON

THE PROPOSED MONTANA POWER COMPANY, PUGET SOUND POWER & LIGHT COMPANY, PORTLAND GENERAL ELECTRIC COMPANY, PACIFIC POWER AND LIGHT COMPANY, AND WASHINGTON WATER POWER COMPANY, COLSTRIP ELECTRIC GENERATING UNITS 3 & 4, 500 KILOVOLT KV TRANSMISSION LINES FROM COLSTRIP TO HOT SPRINGS, MONTANA, AND ASSOCIATED FACILITIES

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CHAPTER ELEVEN Colstrip Site Impact Analysis

11.1. Natural Environment

11.1.1. Air Quality Impacts

11.1.1.1. Cooling Tower Impacts

The function of cooling towers is to dissipate waste heat directly to the atmosphere. Wet cooling towers dissipate heat primarily by evaporating water, and therefore act as both heat and moisture sources. Dry cooling towers transfer heat to the air by conduction and convection, and emit only heat.

A. Potential Cooling Tower Impacts

Although the meteorological consequences of the emission of heat and moisture from cooling towers are not well understood and generally cannot be quantified, the potential for interaction of such emissions with mesoscale and local weather has been recognized (Huff 1972, Boyack et al. 1973, Huff et al. 1971). Hanna and Swisher (1971) reported that the magnitude of the heat and moisture emissions from a 1000 MW power plant is sufficient to possibly interact with such mesoscale phenomena as rain clouds, temperature inversions, and zones containing horizontal gradients of wind and temperature (Hanna et al. 1971). Huff et al. (1971) conjectured that cooling tower effluents may initiate severe weather through a triggering or stimulation effect. On a local scale both wet and dry towers may initiate cloud development and augment natural precipitation (Huff 1972, Boyack et al. 1973, Stockham 1971). Wet towers may also enhance fogging and icing and create a visible plume (Huff 1972. Boyack et al. 1973, Stockham 1971, Huff et al. 1971, Ackermann 1971, EGG 1971, Hall 1962). Dry towers may, on the other hand, have the potential to disperse fog (Boyack et al. 1973).

Two other potential environmental impacts of wet cooling towers are the production of acid mist if the cooling tower and stack plumes mix, and drift deposition. The latter term refers to the process in which a minute fraction of the cooling tower circulating water is broken into tiny droplets and carried out of the tower (Overcamp et al. 1974). These droplets may contain salts or other chemicals which have been concentrated in the circulating water by evaporation.

B. Comparison of Natural-Draft Versus Mechanical-Draft Impacts

As was mentioned in Section 7.1.1. both wet and dry cooling towers can be either natural-draft or mechanical-draft towers. According to Huff et al. (1971), "...actual quantitative measurements of the differential effects of natural-draft and mechanical-draft tower effluents on atmospheric conditions apparently have not been made" (p.6). No other studies are known to have been published since this statement was made.

General agreement in the literature appears to exist with respect to qualitative comparisons of wet natural and mechanical-draft towers. Because of the lower level of discharge from mechanical-draft towers, /1 the general view is that these towers are more likely to produce local effects such as fog and icing problems (Huff 1972, Boyack et al. 1973, Huff et al. 1971, Ackermann 1971). EGG (1971) reported "The modeling results indicate that mechanical-draft towers as currently used will always result in less penetration and greater potential for adverse environmental effects than typical large natural-draft towers" (p. 24). Huff et al. (1971)

concluded as a result of their literature review, "With their higher level of discharge, the natural-draft type would be expected to become involved more readily in the cloud and precipitation producing process in the atmosphere" (p. 7).

C. Modeling and Field Studies

Only a limited number of field and modeling studies have been reported in the literature which have attempted to evaluate the potential impacts of cooling towers.

Stockham (1971) conducted a one-year study of cooling tower impacts at the Keystone 1800 MW coal-fired generating plant located near Shelocta, Pennsylvania. Keystone consists of two 900 MW units with one 244 meter stack and two 99 meter hyperbolic natural-draft wet cooling towers per unit. Field observations and measurements were conducted intermittently during September, November, and December 1969. According to Stockham (1971, p. 44), "While under observations during this study, no adverse weather effects due to the operation of the Keystone Station could be shown conclusively". A possibility of precipitation enhancement during one month of the study was noted. Co-mingling of the cooling tower and stack plumes were detected for distances up to 11,200 meters downwind. /2 This mixing was confirmed by the presence of acid droplets and fly ash particles in the visible portion of the cooling tower plume. As part of the study a mathematical entrainment model was utilized to explain cooling tower plume behavior, but no detailed comparison between model results and observed plume behavior was attempted. Because of the short time period of actual field observations and for other reasons, Stockham concluded that the full environmental effects of natural-draft cooling towers could not be specified conclusively from this study.

Attempts have been made to modify cloud growth models and apply them to wet cooling tower plumes. Both Huff et al. (1971) and EGG (1971) modified the cumulus model developed by Weinstein and Davis (1968). As applied by Huff's group, the cloud model predicted in-cloud liquid water content and vertical velocity, rate of precipitation existing at cloud base, and the maximum vertical extent of the cloud. Wind shear was not included in the model, so predictions of downwind extent of the cloud could not be made. Huff et al. (1971) ran the model for the hybrid wet type cooling towers designed for the proposed 2200 MW nuclear plant to be located at Zion, Illinois on the western shore of Lake Michigan. /3 The modeling results indicated the maximum height of the moist plume would be strongly dependent upon relative humidity and could vary from 1800 to 5500 feet. Results also indicated the cooling tower plumes would have a negligible effect upon warm season precipitation, but might increase annual snowfall one to two inches for distances of about two miles inland from the plant.

The cloud model as modified by EGG (1971) included vertical shear of the horizontal wind and used Gaussian diffusion equations to account for downwind diffusion of water vapor from the plume edges. EGG used the model "to analyze the behavior and subsequent downwind spread of cooling tower plumes" (p.21). Specific attention was given to the conditions necessary for water emitted from cooling towers to lead to the formation of haze and fog. EGG concluded "...moderate winds with stable lapse rates and low moisture deficits (high humidity and generally temperatures colder than about 0°C) provide proper conditions for possible fogging and adverse modifications downwind of typical cooling towers" (p.34). One case of model verification was reported by EGG. Using observed conditions at the Keystone generating plant qualitative agreement was reported for the model downwind plume dispersion and observed conditions.

The same basic Weinstein and Davis cumulus cloud model was applied by Boyack et al. (1973) to evaluate the potential impacts of dry cooling towers. As input to the model, Boyack used characteristics of hypothetical natural-draft and mechanical-draft towers which might be used for 1000 MW nuclear and fossil fuel generating plants. Boyack et al., concluded that potential mesoscale impacts could not be assessed with existing knowledge. Among the conclusions reached about possible local scale impacts were these: the full potential of dry towers to disperse fogs will rarely be realized except in the limited region surrounding the tower; dry plumes are not likely to produce large clouds or clouds capable of producing significant amounts of precipitation; and local ground level heating would be negligible except under transient conditions when temperature rises might reach but not exceed 20°F. The general conclusion reached was "... where quantitative assessment is possible, ...adverse environmental effects are unlikely with the use of dry cooling towers" (p. 351).

Mathematical models for the prediction of the amount of drift deposition from wet cooling towers have been developed by Roffman et al. (1973) and Overcamp et al. (1974). According to Roffman et al. the model is applicable to natural and mechanical-draft towers and accounts for droplet diffusion, evaporation and condensation, and deposition. The model reported by Overcamp et al. predicts drift deposition from natural-draft towers, and calculates the "...effective height of emission of drift droplets, droplet evaporation and sedimentation, and the dispersion of droplets by atmospheric turbulence" (p. 17). No case studies in which model predictions were tested against actual field studies of cooling tower drift were reported by either group of authors. Overcamp et al. did state that experimental studies at the Chalk Point Cooling Tower Project will be undertaken to verify their model.

One comprehensive, combined field and modeling study of the visible plume from mechanical-draft, wet cooling towers has been recently reported by Meyer et al. (1974). The study is being conducted by the Applied Physics Laboratory of John Hopkins University in conjunction with the Detailed Site Evaluation component of Maryland's Plant Siting Program. Field measurements have been made intermittently during the fall of 1973 to the summer of 1974 period at the 560 MW fossil fueled Benning Road generating plant in Washington D.C. Measurements taken include local meteorological data, plant and cooling tower operating parameters, and visible plume behavior. Two approaches were reported with respect to the modeling effort. First of all, field data was used to "...tune currently existing bent-over plume rise formulations" (p. 69). Although the tuning process "...yielded a rather accurate method for predicting visible plume lengths under a variety of meteorological conditions, both near-and-far-field" (p.69), inconsistencies arose between the best methods for predicting plume trajectories and those for predicting plume visibilities./4 For this reason, development was initiated on a "multi-port" numerical plume model which would include numerical integration of the conservation equations (for mass, momentum, and energy); plume geometry transitions after release from multi-cell towers; Taylor's entrainment hypothesis; simulation of complete trajectory, including the bending-over state; and the rate of droplet evaporation and condensation. According to Meyer et al., work on the numerical model is continuing.

To summarize, published field and modeling studies have not produced verified methods for making quantitative predictions of cooling tower impacts on meso or local scales. Existing cloud growth models have been modified and applied to both wet and dry cooling tower plumes. Results of such applications tend to indicate that cooling towers will generally not have significant impact on cloud initiation and precipitation augmentation. Under certain meteorological conditions the cloud models have indicated that wet cooling towers and especially mechanical-draft towers may increase local fogging. However, no quantitative verifications of these models against actual field studies have been reported. Hanna (1972) pointed out:

> ...there are many reasons for being careful in the application of numerical cloud growth models to cooling tower plumes. A major problem is that we possess very little information with respect to cloud microphysics in the mouth of the cooling tower or in the visible plume (p. 795).

A similar situation exists with the prediction of drift deposition. Models exist, but are untested because of the lack of actual cooling tower data. Especially critical to drift modeling is the knowledge of the initial size distribution of the drift droplets. Overcamp et al. referenced a measured size distribution for natural-draft towers, but similar data for mechanical-draft towers have apparently not been published.

Until more field and combinations of field and modeling studies on cooling tower plume behavior such as that reported in progress by Meyer et al. (1974) are completed and published, quantitative assessments of verified accuracy will not be possible.

11.1.1.2. Adequacy of Particulate Ambient Air Standard

Federal and state ambient air standards are designed to protect the public health with a margin of safety and the public welfare against any known or anticipated adverse effects of air pollution. At best these standards reflect existing scientific knowledge of pollution effects, the practicality of standard enforcement, and the social and economic costs of both the pollution and the control of the pollution. Therefore, although compliance with standards may increase the probability of protecting public health and welfare, protection is not necessarily guaranteed.

As an example of how existing scientific knowledge of pollution effects may limit ability to achieve the desired goal of protection of public health and welfare, consider that the air quality criteria documents and air quality standards are written on a single pollutant basis. According to Corn (1972),

> The entire scientific community recognizes that any adverse effects of (urban) pollution on the population are the result of highly complex interaction of particulate and gas phases of ambient air and concomitant weather phenomena. Indeed, the possibility of establishing any (original emphasis) individual pollutant at measured ambient concentrations as "the cause" of effects observed in the laboratory or even in acute air pollution episodes, would be toxicologically "astounding" according to Amdur (1969)."

Corn points out that the single pollutant approach has been applied because

> ...the accumulated "traditional" knowledge of toxicology is inadequate to deal with this problem in toto (original emphasis) (i.e., on a multi-pollutant basis), but is admirably suited to breaking the problem into its individual components for study.

Corn goes on to state, "After many years of study whether the whole (i.e., the actual effects of urban pollution) will ever be equal to the sum of its parts (i.e., the individual pollutant effects) is anybody's guess at this time." (p. 466). While Corn's comments were originally addressed to urban pollution, they probably also apply to the complex mixture of gaseous and particulate pollutants emitted by large fossil fuel power plants in rural settings.

The remaining portions of this section attempt to present a case that the existing suspended particulate standards may be inadequate even on a single pollutant basis to protect public health and welfare. The adequacy of the existing sulfur dioxide standards are discussed in Section 11.1.5.

Existing particulate standards are written on a mass concentration basis. They specify maximum allowable values of total weight of particulate contained in a given volume of air—so many micrograms per cubic meter. However, as pointed out by Friedlander (1973), "Total weight is an inadequate measure of particulate pollution and its effects" (p. 1116). To properly assess the environmental impact of particulates both size and chemical composition must also be considered./5 Increasing evidence discussed below points to one particular size group of particulates, the so-called small particles in the approximate 0.1 to 1 micron (u) range, as having particularly significant potential environmental effects.

A. Residence Time in the Atmosphere

The residence time of particulates in the lower atmosphere which determines how far the particulates may be transported from their emission source is related to particle settling velocity, agglomeration and coagulation rates, washout and rainout rates, and so on (Hidy 1972). The efficiency of these processes is in turn related to particle size and the number of particles per unit volume rather than mass concentrations. The very small particles, less than about .01u undergo rapid rates of removal due to agglomeration (Junge 1963 and Williamson 1973). The very large particles, those larger than about 40u in diameter, have large settling velocities and are rapidly removed from the atmosphere by sedimentation (Junge 1963). Thus the very large particles which will dominate total mass concentrations will generally be found only in the immediate vicinity of their emission source. Particles in the approximate 0.1 to 1u range have settling velocities which are small compared to air motions /6 (U.S. Dept. of HEW 1969). According to Higby (1972) the most efficient removal mechanism for 0.1 to 1u particles located at an altitude of about 2km is rainout. Based upon his estimates of order of magnitude removal rates, the shortest time period required by more continuous atmospheric processes to completely deplete his assumed initial concentrations of 0.1 to 1u particles (originally at an altitude of 2km or nearer the ground) is about 10^5 seconds (about one day). Thus this size range of particles may be transported significant distances from an emission source.

B. Particulate Climatic Effects

Particulates in the atmosphere have two recognized roles in affecting climate: they interact directly with incoming solar radiation and thereby influence the earth's energy balance (Williamson 1973, Kerker 1972, U.S. Dept. of HEW 1969); and they initiate phase changes of water and are therefore essential for cloud formation and precipitation (Williamson 1973, Junge 1963, U.S. Dept. of HEW 1969). In both of these roles the key characteristics of the particulates include size distribution and chemical composition as well as total weight per unit volume.

Suspended particulates interact with solar radiation through absorption and scattering. Absorption of solar radiation may result in local atmospheric warming which would in turn tend to increase surface temperature (Williamson 1973). Scattering by particulates may increase the reflectance, or albedo, of the earth-atmosphere system, a process which would reduce surface temperatures (U.S. Dept. of HEW 1969 and Williamson 1973). Williamson states, "It appears that whether scattering or absorption is the dominant effect is determined by the size, chemical composition, and distribution of the particles" (p. 108).

The spectral region of maximum intensity of solar radiation is visible light (Hess 1959). Because they are of the same general dimensions as wavelength of visible light, particulates in the size range of about 0.1 to 1.0u are most effective in scattering such light. Therefore, increased emissions of these small particles to the atmosphere "...may cause changes in the delicate heat balance of the earth-atmosphere system, thus altering worldwide climatic conditions" (U.S. Dept. of HEW 1969, p. 44).

The ability of atmospheric particulates to act as condensation nuclei is directly related to particle size and composition. Because only small values of water vapor supersaturations can exist in the atmosphere, the very small particles do not normally act as condensation nuclei. Junge (1963) places the dividing line between active and inactive condensation nuclei at about particle radii of 0.1u, while Stern et al. (1973) indicate that the diameter of active condensation nuclei are usually between 0.01 and 1u. Not all particles of the same size act as nuclei to the same extent (Junge 1963, Stern et al. 1973) because the affinity of the surface of a given particle for water is important to nucleating efficiency. The number, composition and size distribution of active nuclei together with the degree of water vapor supersaturation will determine the resulting water droplet size distribution (Corrin et al. 1974). The droplet size distribution is related to the stability of the resultant cloud (Junge 1963) and hence the likelihood of precipitation. Large numbers of small, activated nuclei will generally produce a stable cloud containing concentrations of small water droplets, while a small number of large nuclei (larger than about 1.0u) would be likely to produce a cloud with low concentrations of large droplets (Corrin et al. 1974). The potential for droplet growth to precipitation size is probably greater for the second case.

C. Particulate Visibility Effects

The impact of suspended particulates on visibility is related to the interactions of particulates with visible light, including absorption and scattering. According to the Air Quality Criteria for Particulate Matter (U.S. Dept. of HEW 1969), the scattering interaction can be assumed to be the predominate effect on visibility. For reasons previously discussed, particulate scattering of visible light is due primarily to those particles in the approximate 0.1 to 1.0u, size range. Thus the total weight of particulate per unit volume is not necessarily related to the impact of that particulate on visibility. Friedlander (1973) stated:

> It is quite possible that the total particulate mass may be decreasing in a given geographical region while air quality declines because the mass of material in the submicron range increases. Just such a development may have been taking place in Los Angeles where total mass of suspended particulates has decreased as control measures on certain types of stationary sources such as back-yard incinerators were implemented. At the same time, there is some evidence that visibility has actually decreased over the same period (p. 1116).

D. Particulate Health Effects

Widespread recognition exists that potential adverse impacts of suspended particulate on public health are not solely a function of total weight of particulate per unit volume of air. Probably the more accepted viewpoint is expressed by Mercer et al. (1972).

> The toxicity of airborne particles depends on their aerodynamic characteristics, which govern the probability and site of the deposition in the respiratory tract, and on their physical and chemical properties, which determine their subsequent retention and toxic action in the body (p. xiii).

Both gaseous particulate air pollutants enter the human body primarily through the respiratory system (U.S. Dept. HEW 1969). The respiratory system is often described in terms of three main sections: the nasopharyngeal structure; the tracheobronchial system; and the pulmonary structure./7 Of these three sections the pulmonary or alveolar section is generally emphasized as the most significant in terms of particulate penetration and deposition because it is within this section that the exchange of oxygen and carbon monoxide occurs between the blood and air, and because according to Stern et al. (1973) the residence time of particles reaching this region "...is measured in weeks, months, or years" (p. 131).

Because of the structure and the various defense mechanisms of the respiratory system, only particles in a certain size range, the so-called "respirable" fraction, have a high probability of reaching the pulmonary regions. Different values have been reported for this size range, including the approximate 0.1 to 2u range of Stern et al. (1973) and a range of 0.05 to 5u given in a report by the American Thoracic Society (1973). Walbott (1973) and Natusch et al. (1974) reported that particles less than about 1.0u are deposited in the alveolar regions, while Corn (1972) states that 1.0u radius "...is a size in the midrange of particle sizes associated with pulmonary compartment deposition" (p. 469). The Air Quality Criteria for Particulate Matter (1969) contains the following conclusions with respect to alveolar deposition:

> 1. There is a maximum efficiency of (alveolar) deposition at a size between about 1 and 2u.
>
> 2. There is a minimum efficiency for a size of around 0.5u.
>
> 3. The percentage of particle deposition for sizes less than 0.1u is just as great as for sizes more than 1u... (p. 119).

This same document also states:

> ...the importance of the second conclusion (#2 immediately above) should not be over emphasized, as it refers only to the probability of deposition. If their number...is relatively great then particles in the 0.1u to 0.5u size region may be as important as smaller and larger particles in provoking toxic response (p. 119).

While disagreement evidently exists with respect to upper and lower bounds of the "respirable" region, it probably does contain particle sizes in the approximate 0.1 to 1.0u range.

Recent studies of the emissions from coal-fired power plants have indicated that toxic trace elements may be concentrated on the small fly ash particles.

Lee et al. (1973) reporting on an analysis of fly ash from a coal fired power plant stated "Particles 1.5u in diameter contained greater quantities of cadmium, chromium, manganese, and lead than larger sized particles" (p. 856).

Natusch et al. (1974) collected fly ash samples from eight power plants in the United States. Both fly ash retained in the emission control system and airborne fly ash leaving the plant were analyzed for trace metal content as a function of particle size. Results indicated that "The toxic trace elements arsenic, antimony, cadmium, lead, selenium, and thallium were found to be most concentrated in the smallest respirable particles emitted from coal-fired plants" (p. 202). Natusch et al. noted that this finding has significance in terms of environmental health because the absorption efficiency for most trace elements in the alveolar regions is 50 to 80%. Natusch et al. proposed that the concentration on the small particles may be due to a volatilization surface deposition process. The trace elements or their compounds are volatized in the high temperature combustion zone. They then recondense or adsorb onto the large available surface area per unit mass provided by the small particles.

Kaakinen et al. (1974) conducted a trace element study on a pulverized coal-fired power plant to determine the fate of trace elements from coal combustion. The elements including copper, antimony, zinc, arsenic, molybdenum, and lead were found to be preferentially concentrated on the smaller particles in the outlet gas streams. The degree of increased concentration of these elements increased as the particle specific surface area increased (as particle size decreased). Kaakinen et al. concluded that the volatilization - recondensation or adsorption model proposed by Natusch et al. fitted their observations very well.

E. Summary

The potential impact of suspended particulate matter on climate, including the heat balance of the earth-atmosphere system and cloud and precipitation initiation, on visibility, and on environmental health is related to both particle size and chemical composition, not merely total weight per unit volume. Also, as stated by Friedlander (1973) "Particles in the 0.1 - 1.0u range generally have a much greater impact on public health, visibility, and cloud nucleation when compared to the same weight of larger particles" (p. 1116). Federal and state ambient air particulate standards based only upon total weight of particulate matter per unit volume may therefore not adequately protect public health and welfare. Particulate emission sources such as power plants which meet existing total weight per unit volume standards but which emit significant amounts of potentially toxic submicron sized particulates may still have unacceptable environmental impacts.

11.1.1.3. Air Quality Model Analysis

A. Diffusion Model Selection

The emissions from proposed Units 3 and 4 would raise the ambient levels of several pollutants. The degree to which such levels would be affected must be estimated in order to determine if ambient standards would be violated. Estimates of ambient air pollution concentrations are generally derived through the use of diffusion modeling to simulate the pollutant effect of industrial facility operation. Modeling techniques combine the polluting characteristics of the emission sources with various physiographic and meteorological factors through a series of equations to provide pollutant concentration estimates.

Several diffusion models are available to facilitate the estimation of ambient pollutant concentrations. Mathis et al. (1973) has reviewed the existing models. The models generally differ in the approach used to solve the turbulent diffusion equation which is given in Appendix A7.

In its complete form the turbulent equation is difficult to solve, and hence various simplifying assumptions regarding the nature of atmospheric turbulence and the nature of the pollutants themselves are normally applied in obtaining solutions. Different models apply different levels of simplifying assumptions. In general the more sophisticated the model (i.e., the fewer simplifications assumed) the greater the amount and detail of emission rate, chemical, and meteorological data required to run the model. Increased sophistication can therefore result in decreased practical applicability.

The model most widely used in atmospheric diffusion studies is the Gaussian plume model (Mathis et al. 1973, p. 8). The positive features of this model include relative simplicity, limited input data requirements, and the fact that "...Gaussian plume models have proved to be, by and large, reasonably successful in explaining observed (effluent) concentration patterns..." (Slade 1968, p. 100). For these reasons and because the Gaussian model can be used to provide concentration estimates for the periods and situations needing to be analyzed in eastern Montana, this model was selected for use in this study.

The input data required by the Gaussian model include: a source inventory consisting of source location, emission rates, and effective plume heights; meteorological data including mean wind speed and direction and atmospheric mixing depths; and empirically derived dispersion coefficients. The dispersion coefficients are the horizontal and standard deviations of the Gaussian plume concentration distribution and are a function of atmospheric stability and the distance downwind of the source. The emission rate data for Colstrip Units 1, 2, 3, and 4 given in Table 11-1 were obtained from MPC with the exception of the trace element emission rates (which were calculated from coal analyses performed for the state). Effective plume heights were calculated using stack parameters supplied by MPC and Briggs' (1969) plume rise equations (see Appendix A11). The meteorological data for Colstrip were collected by the Department of Earth Sciences of MSU and are discussed in Section 10.1.1. Because dispersion coefficient data applicable to the semi-rugged terrain of the Colstrip region was not available, the previously mentioned MSU group also carried out a diffusion study at Colstrip to obtain new dispersion coefficient data. The preliminary results of this study were incorporated into this report as discussed below.

The basic assumptions of the Gaussian models used for this report include:

TABLE 11-1

Emission Rates
(g/sec)

Effluent	Units 1 & 2 Combined	Units 3 & 4 Combined	Units 1 - 4 Combined	Source
SO_2 (sulfur dioxide)	854	1912	2766	MPC
NO_x (oxides of nitrogen)	597.8	1268	1865.8	Westinghouse
Particulate	383.2	108.4	141.6	MPC
As (arsenic)	.038	.084	.122	EPD
B (boron)	.25	.55	.80	"
Ba (barium)	1.2	2.7	3.9	"
Be (beryllium)	.0019	.0042	.0061	"
Br (bromine)	.19	.42	.61	"
Cd (cadmium)	.0015	.0034	.0049	"
Cl (chlorine)	.75	1.69	2.44	"
Co (cobalt)	.00038	.00084	.00122	"
Cr (chromium)	.001	.025	.036	"

TABLE 11-1 (cont.)

Emission Rates
(g/sec)

Effluent	Units 1 & 2 Combined	Units 3 & 4 Combined	Units 1 - 4 Combined	Source
Cu (copper)	.029	.064	.093	"
Eu (europium)	.00030	.00068	.00098	"
F (flourine)	.26	.59	.85	"
Ga (gallium)	.011	.025	.036	EPD
Ge (germanium)	.009	.020	.029	"
Hf (halnium)	.0006	.0014	.0020	"
Hg (mercury)	.013	.030	.043	"
La (lanthanum)	.0029	.0059	.0085	"
Li (lithium)	.038	.084	.122	"
Mn (manganese)	.38	.84	1.22	"
Mo (molybdenum)	.009	.020	.029	"
Nb (niobium)	.0006	.0014	.0020	"

TABLE 11-1 (cont.)

Emission Rates
(g/sec)

Effluent	Units 1 & 2 Combined	Units 3 & 4 Combined	Units 1 - 4 Combined	Source
Ni (nickel)	.13	.30	.43	"
Pb (lead)	.038	.084	.122	"
Ra (radium 226)*	1.1	2.6	3.7	"
Sb (antimony)	.007	.016	.023	"
Sc (scandium)	.0008	.0017	.0025	"
Se (selenium)	.008	.017	.025	EPD
Sm (samarium)	.0019	.0042	.0061	"
Sr (strontium)	.17	.38	.55	"
Ta (tantalum)	.00019	.00042	.00061	"
Tb (terbium)	.00022	.00050	.00072	"
Ti (titanium)	.30	.68	.98	"
Th (thorium)	.0019	.0042	.0061	"
U (uranium)	.0008	.0017	.0025	"

* The emission rate for radium is reported in Ci/sec.

TABLE 11-1 (cont.)

Effluent	Emission Rates (g/sec) Units 1 & 2 Combined	Units 3 & 4 Combined	Units 1 - 4 Combined	Source
V (vanadium)	.023	.052	.075	"
Y (yttrium)	.004	.010	.014	"
Yb (ytterbium)	.0011	.0025	.0036	"
Zn (zinc)	.38	.84	1.22	"
Zr (zirconium)	.012	.027	.039	"

The emission rates in this table are based upon either design guarantees (NO_2 and SO_2) or average coal content data. As discussed in Section 8.3 the heterogeneous nature of the coal may cause these rates to vary.

The trace element emissions were calculated from Table ____ in Section 8.4.4.3. As Table ____ data are emission rates for Units 3 or 4 only, an extrapolation to the combined emissions for Units 1 through 4 was necessary. This extrapolation was calculated using the known ratio of the sulfur dioxide emission rate for Units 3 or 4 to the total rate for Units 1 through 4.

1) A binormal plume concentration distribution in the horizontal and vertical./8

2) Wind speed, wind direction, and atmospheric stability are representative of the atmospheric layer between the surface and the mixing layer height and do not change with downwind distance.

3) The emission rate is uniform.

4) The gaseous and particulate constituents of the power plant plume are nonreactive and are completely reflected at the ground./9

5) Particulates behave as gasses, meaning that their settling velocities and other scavenging processes are neglected.

Three separate diffusion models were selected to provide ambient concentration estimates in this study. Two of the models are Gaussian, while the third was a non-Gaussian dilution model which resulted from the Colstrip diffusion study.

B. Dilution Simulation

The non-Gaussian dilution model was applied to give a preliminary indication of whether existing short term air quality standards would be exceeded. For reasons discussed below this model is capable only of indicating potential violations and cannot be used to show that standards will not be violated.

The dilution model used to estimate peak ground level concentrations of pollutants was derived from a preliminary analysis of the data collected during the Colstrip diffusion study conducted by MSU. This approach relies on several measurements of essentially ground level concentrations of an ice nuclei (silver iodide, AgI) plume released from a 300-foot tower located on a hill 200 ft. above the proposed plant base at Colstrip. This method provides a dilution factor which is the ratio of the measured ice nuclei concentrations at or near the ground (X_{AgI}), to the ice nuclei production rate (source emission rate = Q_{AgI}). This ratio can be applied to a proposed stack emission rate, and the corresponding maximum ground level concentration can be estimated.

In the case of sulfur dioxide (SO_2), the pollutant most likely to exceed state and federal standards, let the source strength and ground level concentrations be represented by Q_{SO_2} and X_{SO_2} respectively. Knowing Q_{SO_2} from plant design data, one can estimate X_{SO_2} for the conditions under which X_{AgI} was monitored by:

$$X_{SO_2} = Q_{SO_2} \frac{X_{AgI}}{Q_{AgI}}$$

This approach has several advantages which include:

1) No assumption need be made regarding the specifics of the model. For example it is not necessary to assume a Gaussian (or any other) plume distribution. It is not necessary to know the specific distribution of the plume (for a Gaussian plume, horizontal and vertical standard deviations, σy and σz) as a function of downwind distance and atmospheric stability.

2) Assumptions regarding plume reflection and effect of a trapping lid need not be made.

3) The difficult problem of plume rise can be ignored. Any plume rise would reduce ground level pollutant concentrations.

4) The approach will be conservative in that estimates derived from it should be higher than expected as only maximum criteria were used in the development of the dilution factor.

5) The method is simple and convenient.

6) The method utilizes data collected at Colstrip. Therefore, the model can be used for some of the periods and situations that need to be analyzed in eastern Montana.

The data used to calculate the dilution factor were primarily the ice nuclei concentrations measured during low level (about 50 feet above ground level) aircraft flights through the plume. An NCAR (National Center for Atmospheric Research) accoustical ice nucleus counter (Langer and Weickman 1971, Langer 1973) was used to measure the ice nuclei concentrations.

In calculating the dilution factor, only the maximum concentration observed on each traverse through the plume was used. Also, although these concentrations were actually nearly instantaneous values, they were treated in the calculation as though they were one hour means. Short term averages may be significantly greater than one hour means (by a factor of two to seven depending on the time averaging formula used). This approach will probably result in high estimates of pollutant concentrations.

In those cases where a ground-based NCAR counter was available, actual hourly means of ice nuclei concentrations were calculated. These data also were included in the formulation of a dilution factor.

The reliability of the NCAR counter has been the subject of some debate (see Hobbs & Locatelli 1970, Biggs 1970, Langer 1971), and consequently, the subject deserves discussion here. At least some commercially manufactured versions of the NCAR counter have yielded unreliable data. Also, even a properly configured unit requires a skilled operator, and the lack of one has probably lead to faulty data in some past studies (Super 1974).

With the present state-of-the-art, the absolute accuracy of any ice nucleus counting device is still not completely known. However, the reliability of the type of NCAR counter used for the Colstrip studies has been demonstrated at the national test facility for AgI generator calibration. This facility, located at Colorado State University (CSU), utilizes a large isothermal cloud chamber for testing ice nuclei counters and generators. Langer (1971) reported excellent agreement between a NCAR counter similar to that used at Colstrip and the CSU facility results. The comparison was made using the same type AgI generator and solution used at Colstrip.

Super (1974) reported a very good agreement between AgI concentration estimates derived from NCAR counter data and the expected AgI generator output derived from the CSU calibration. Super (1974b) showed the results of ten concentration estimates made from 3 to 23 miles downwind of the AgI generator. These estimates, all made during light winds (approximately 4 mph) at the generator indicated that the generator output ranged from only 0.5 to 1.0 x 10^{13} nuclei per second. This demonstrates a high degree of reliability of the experiments. Moreover, the concentration estimates are in good agreement with generator output according to the CSU calibration. The latter was made for two conditions; at natural tunnel draft (near calm) and at maximum tunnel flow (approximately 23 mph across burner head). For the approximately 30 g/hr AgI consumption used in the studies cited, and at Colstrip, an output of 0.5 x 10^{13} nuclei/sec would be expected for near calm winds. For strong winds, which decrease coagulation, the output increases to 17 x 10^{13} nuclei/sec.

The AgI generator used at Colstrip had a large fan directed at the burner head. The fan was intended to both increase ice nucleus (AgI) production and stabilize it from variable wind speed effects. It is probable that the fan caused production to approach 17 x 10^{13} nuclei/sec. Two flux estimates have been made using a generator without a fan, but with good ventilation due to generator level wind speeds of 15 mph. This resulted in rates of 8 and 11 x 10^{13} nuclei/sec (Super and McPartland, 1973).

Based on the above results and discussion, it appears reasonable to assume the fan-type AgI generator at Colstrip had a production rate of approximately 10^{14} nuclei/sec.

The uncertainties of the AgI emission rate is not the only drawback that may be associated with a dilution factor approach. While monitoring by aircraft the downwind distance of the flight frequently does not pass through the point of the maximum concentration. However, most of the traverses were positioned within the range of distances at which maximums would be expected (.5 - 5 miles). Also, only the maximum values were used in developing the dilution factor. Some of the many flights conducted probably sampled maximum concentrations. Also some contour flights passed through the plume parallel to the plume axis. These flights monitored concentrations equivalent to any recorded for that situation. Another drawback of the dilution approach is that extrapolating dilution concentrations to meteorological conditions other than those existing during the actual dilution measurements is probably not valid. Thus the maximum measured dilution concentrations may not represent the maximum possible concentrations for all meteorological conditions which might occur at Colstrip. For this reason the dilution model cannot be used to demonstrate that short term standards will not be exceeded.

Photolytic decay of the nucleating abilities of certain complex AgI compounds has been shown to occur. If such a decay occurred during the tracer study at Colstrip, absolute measurements of ice nuclei concentrations would not reflect the effects of dispersion and diffusion of the AgI smoke alone, and maximum concentrations would be underestimated. However, the ammonium complexed AgI used in the Colstrip research has not exhibited significant photodecay tendencies. This is discussed at length in a forthcoming paper (Super, Heimbach and McPartland 1974a).

Addressing annual standards with a dilution factor is not practical, as this method is applicable only for short periods.

From the data collected the ice nuclei concentrations versus distances for several wind speeds are plotted in Figure 11-1. Three curves were drawn for different wind speed categories. Points plotted would represent periods of one hour or less. Calculating a dilution factor from the maximum value on the plot (18,000 nuclei/liter) would provide the following.

X_{AgI} = 18,000 nuclei/l = 18 x 10^6 nuclei/m
(maximum concentration recorded)

Q_{AgI} = 1 x 10^{14} nuclei/sec (Q = generator emission rate)

Dilution Factor (F) =

$$\frac{X_{AgI}}{Q_{AgI}} \; \frac{= 18{,}000{,}000 \text{ nuclei/m}^3}{= 10^{14} \text{ nuclei/sec}}$$

$F = 1.8 \times 10^{-7} \text{ sec/m}^3$

1. Dilution Model Results

Assuming that all sulfur dioxide emissions from Units 1-4 were emitted from one source at tower top (about 500 feet above plant base) the dilution factor F could be applied. The assumption that all emissions come from one source would result in estimates higher than can actually occur, as the emissions from four individual stacks would be diluted with environmental air more than the one single emission assumed here. Calculations for the worst possible case indicated by the low level and ground level measurements are as follows:

$F = 1.8 \times 10^{-7} \frac{\text{sec}}{\text{m}^3}$ from above.

Q_{SO_2} = 2766 g/sec (total SO_2 emission rate from Units 1-4)

Therefore, $X_{SO_2} = F \, Q_{SO_2}$

$$= 1.8 \times 10^{-7} \frac{\text{sec}}{\text{m}^3} \times 2766 \text{ g/sec}$$

$$= .000498 \text{ g/m}^3 \times \frac{1{,}000{,}000 \text{ ug}}{\text{g}}$$

$$= 498 \text{ ug/m}^3 \text{ for 1 hour}$$

The estimate of 498 ug/m3 does not exceed Montana's one hour standard (650 ug/m3).

The time averaging equation used to convert from one hour estimates to three and 24 hour estimates is shown below:

$$X_f = X_i \left(\frac{T_i}{T_f}\right)^{0.2} \qquad \text{Turner (1969)}$$

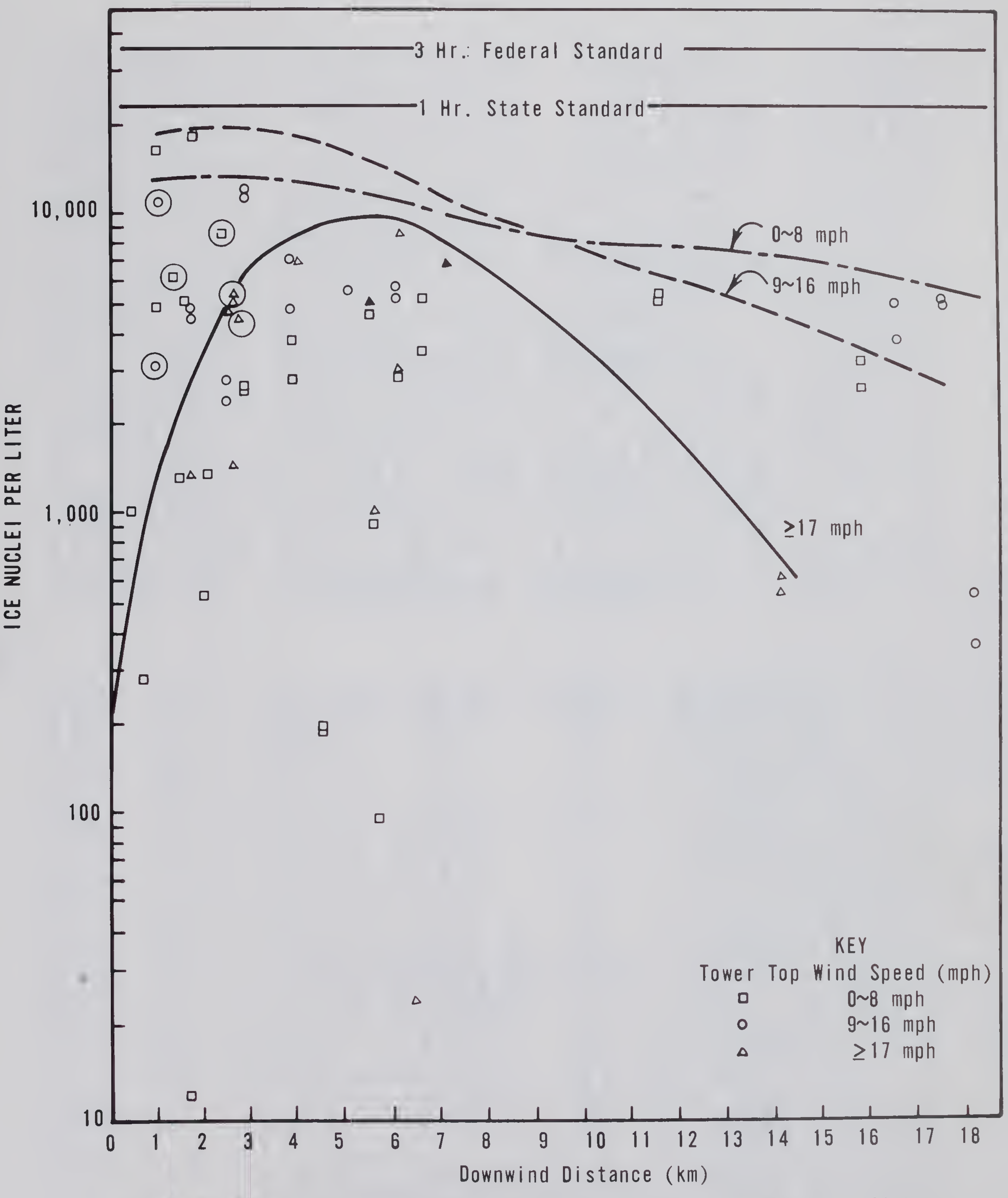
Where X_f = concentration for period T_f (ug/m)

X_i = concentration for period T_i (ug/m)

T_f = period for which concentration is desired (hr)

T_i = period for which dilution model projects concentration (hr)

Using time averaging techniques one hour concentrations can be converted to 3 and 24 hour estimates by multiplying by .80 and .53 respectively./10 Such calculations will show that the respective maximum for 3 and 24 hours will be 400



Ice Nuclei Concentrations versus Downwind Distance. The Low Level Airborne are Quasi-Instantaneous Values and the Ground Measured Data (Circled) are Hour Averages. The 2 Passes along the Core of the Plume have their Triangles Shaded in.

FIGURE 11-1

ug/m ^{3} and 264 ug/m ^{3}. Table 11-2 lists the maximum ground level SO_2 concentrations calculated as a function of downwind distance for 1, 3, and 24 hour averaging periods. Also included is an estimation of the frequency of occurrence of the maximum concentrations calculated by comparing the meteorological conditions present when the maximum ice nuclei concentrations were measured with the year of meteorological data collected at Colstrip by MSU. It should be repeated that these estimates are conservative from the standpoint that only maximizing criteria were utilized in their calculation.

Corresponding estimates for other pollutants may be determined by applying the following equation.

$$X_{unknown} = X_{SO_2} \frac{Q_{unknown}}{Q_{SO_2}}$$

Thus, by multiplying the sulfur dioxide estimate by the ratio of the specified pollutant emission rate to the SO_2 emission rate, one can obtain the estimate for the specified pollutant.

Table 11-3 lists the maximum ground level concentrations of the major pollutants calculated using the dilution model. Both the estimated plant contribution and the sum of the maximum average background levels and the plant contribution are reported.

For comparison with Table 11-3 values, the Montana and Federal ambient air standards are given in Appendix A3.

According to Tables 11-2 and 11-3, the dilution model indicates that only one ambient air standard, the Montana 24-hour sulfur dioxide standard, might be approached by Colstrip Units 1 through 4 operation. However, because this model is not capable of assessing the range of meteorological and hence dispersion conditions which occur at Colstrip, these results do not mean that ambient air standards would not ever be exceeded.

C. Gaussian Models

Figures 11-2, 11-3, 11-4, and 11-5 are plots of the horizontal and vertical dispersion coefficients versus downwind distance used as input data for the long and short term Gaussian models described below. The plots represent the preliminary results of the Colstrip diffusion study conducted by MSU. A brief description of the diffusion study is given in Appendix A8.

In Figures 11-2 and 11-4 the horizontal and vertical dispersion coefficients were stratified by MSU versus the 300-foot wind direction range (i.e., the variation in the wind direction) measured at Colstrip, while in Figures 11-3 and 11-5 the coefficients were stratified versus the standard deviation of the horizontal and vertical wind components, respectively, derived from Colstrip Gill UVW anemometer data. Neither stratification is satisfactory as considerable overlap occurs among the individual categories.

The four figures indicate that both the horizontal and vertical plume dispersion at Colstrip will be more rapid than that expected from the Pasquill stability curves given by Turner (1970). The increased dispersion may be caused by increased mechanical turbulence generated by the semi-rugged Colstrip terrain over that generated by the flat terrain associated with the Pasquill curves. Increased horizontal dispersion at Col-

PLEASE RETURN

TABLE 11-2

Maximum Ground Level Sulfur Dioxide Estimates (mg/m^3)
by Dilution Techniques

Wind Speed (mph)	Distance Downwind (Km)	1-Hr. Conc. Estimate	Max. Prob. Frequency Per 4 Days	Wind Dir. (deg.)	3-Hr. Conc. Estimates	Max. Prob. Frequency Per Year	24-Hr. Conc. Estimates	Max. Prob. Frequency Per 3 Mon.	Wind Dir. (deg.)
-	standard	650	1	-	1300	0	260	1%	-
9 - 16	1	470	10	300	377	0	249	2%	300
	1.7(max.)	498	10	300	400	0	264	2%	300
	2	496	10	300	398	0	263	2%	300
	3	481	10	300	386	0	255	2%	300
	4	426	10	300	342	0	226	2%	300
17	5	370	14	275	297	0	196	3.3%	280
	6	332	14	280	267	0	176	3.3%	280
0 - 8	8	254	6	290	204	0	135	1.2%	300
	10	216	6	340	173	0	114	1.2%	330
	12	199	6	340	160	0	105	1.2%	330
	15	177	6	340	142	0	94	1.2%	330
	18	149	6	340	120	0	79	1.2%	330

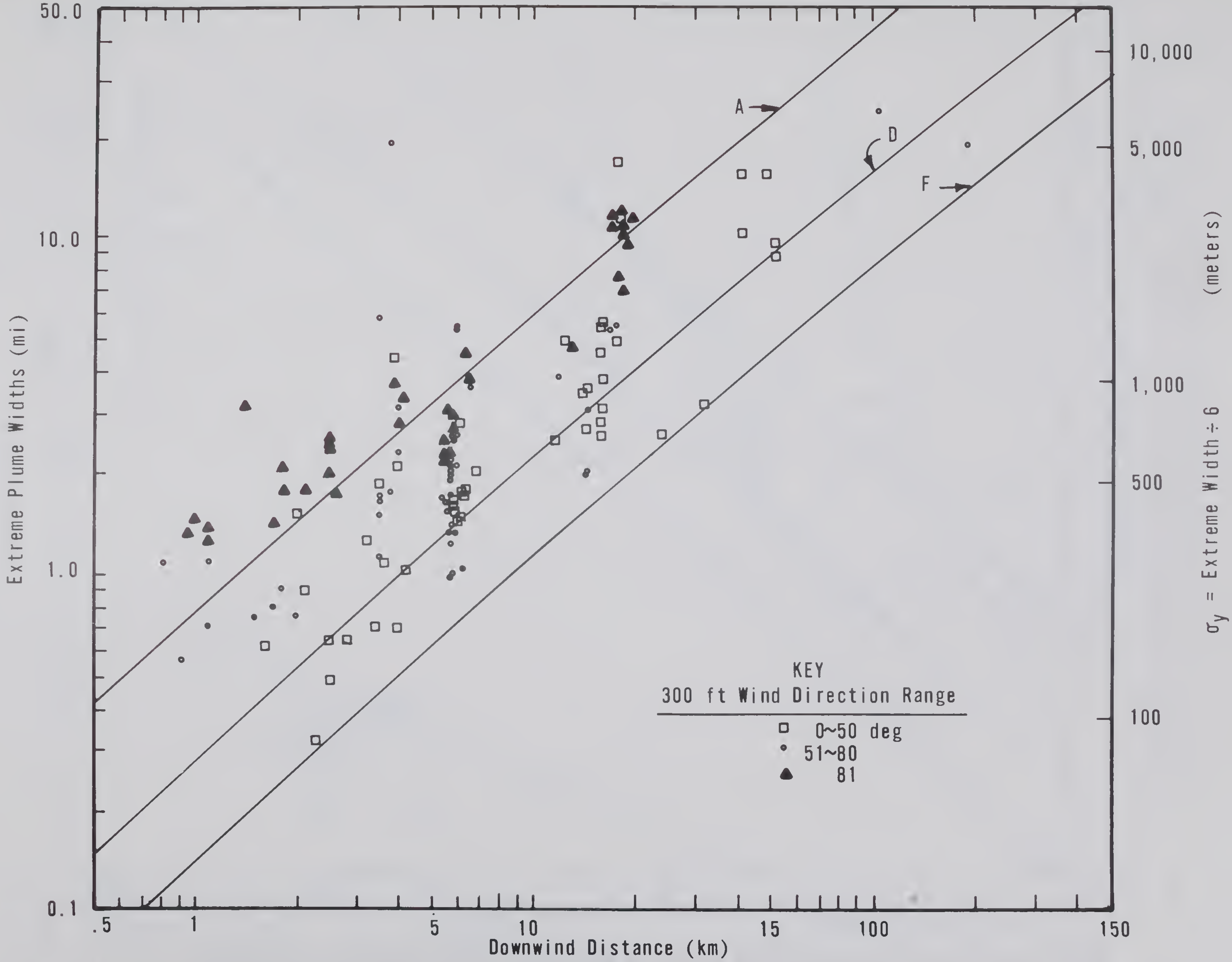
TABLE 11-3

DILUTION MODEL

Maximum Ambient Concentrations Expected For Major Pollutants (g/m^3)

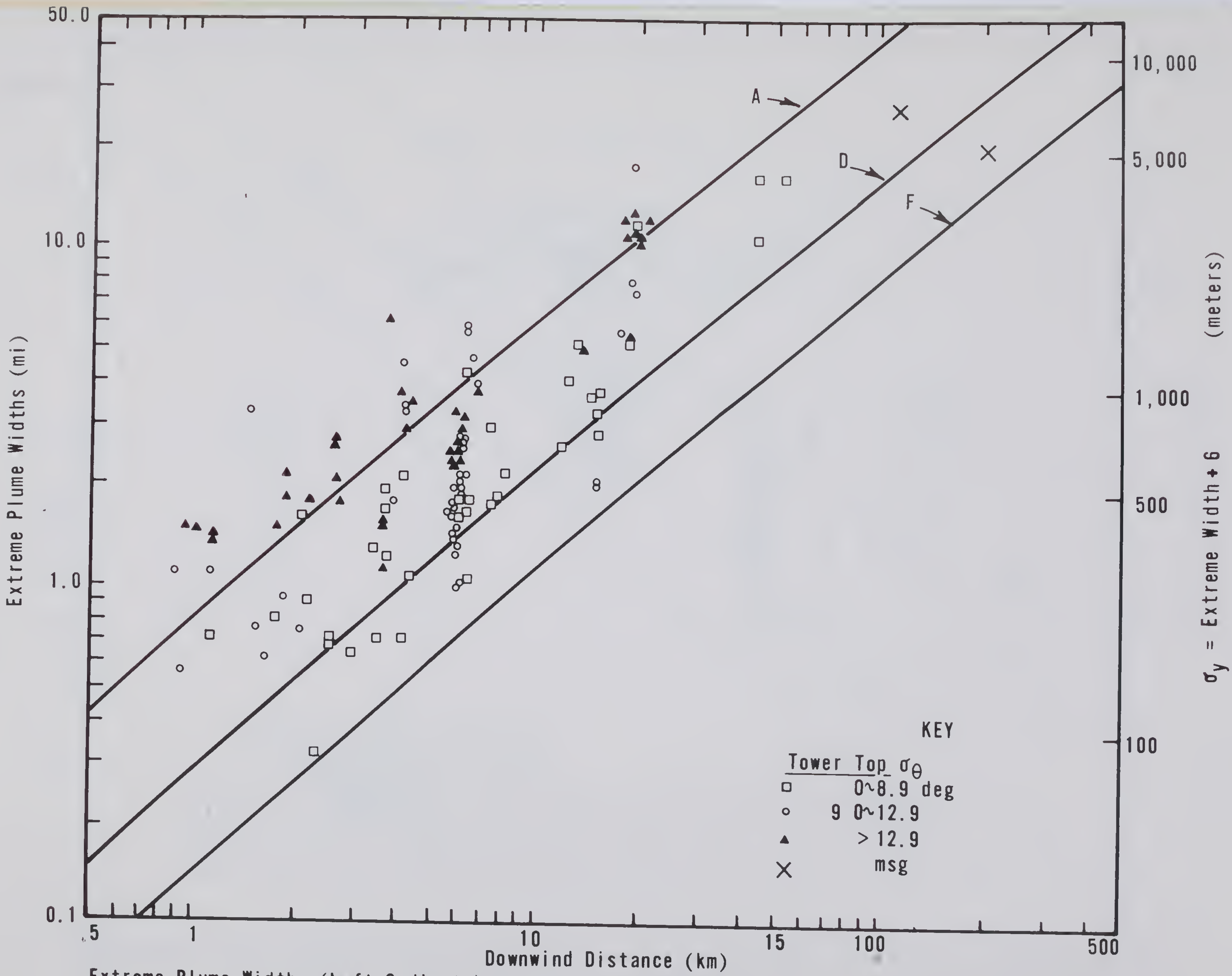
	Period					
	1 hr.		3 hr.		24 hr.	
Pollutant	Plant Contrib.	Total	Plant Contrib.	Total	Plant Contrib.	Total
SO_2	498	504	400	404	264	267
NO_2	336	354	270	284	178	187
TSP	25	138	20	111	13	73
Ozone	0	156	0	125	0	83
Flouride	.15	---	.12	---	.08	

Assuming P = 1 atm and T = 298^0C and all emitted flouride is gaseous hydrogen flouride (a worst case approach) the flouride concentrations in micrograms per cubic meter can be converted to parts per million by multiplying by 1.2×10^{-3} ppm/μg/m^3 . Similarly the sulfur dioxide concentrations can be converted by multiplying by 3.8×10^{-4} ppm/μg/m^3 .



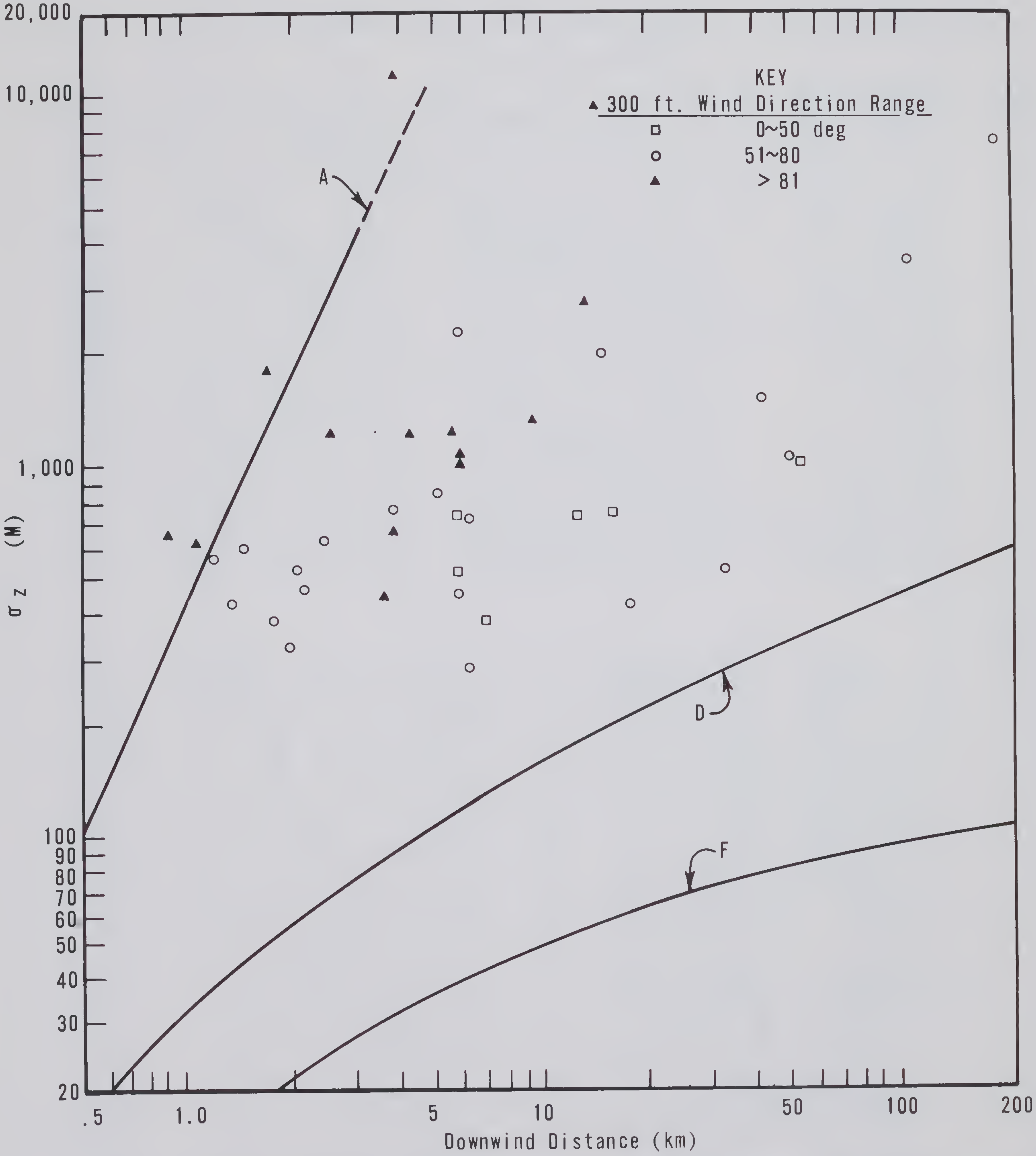
Extreme Plume Widths (Left Ordinate) as a Function of Downwind Distance. The Right Ordinate gives a Scale for Converting these Widths to Horizontal Standard Deviations in Meters.

FIGURE 11-2



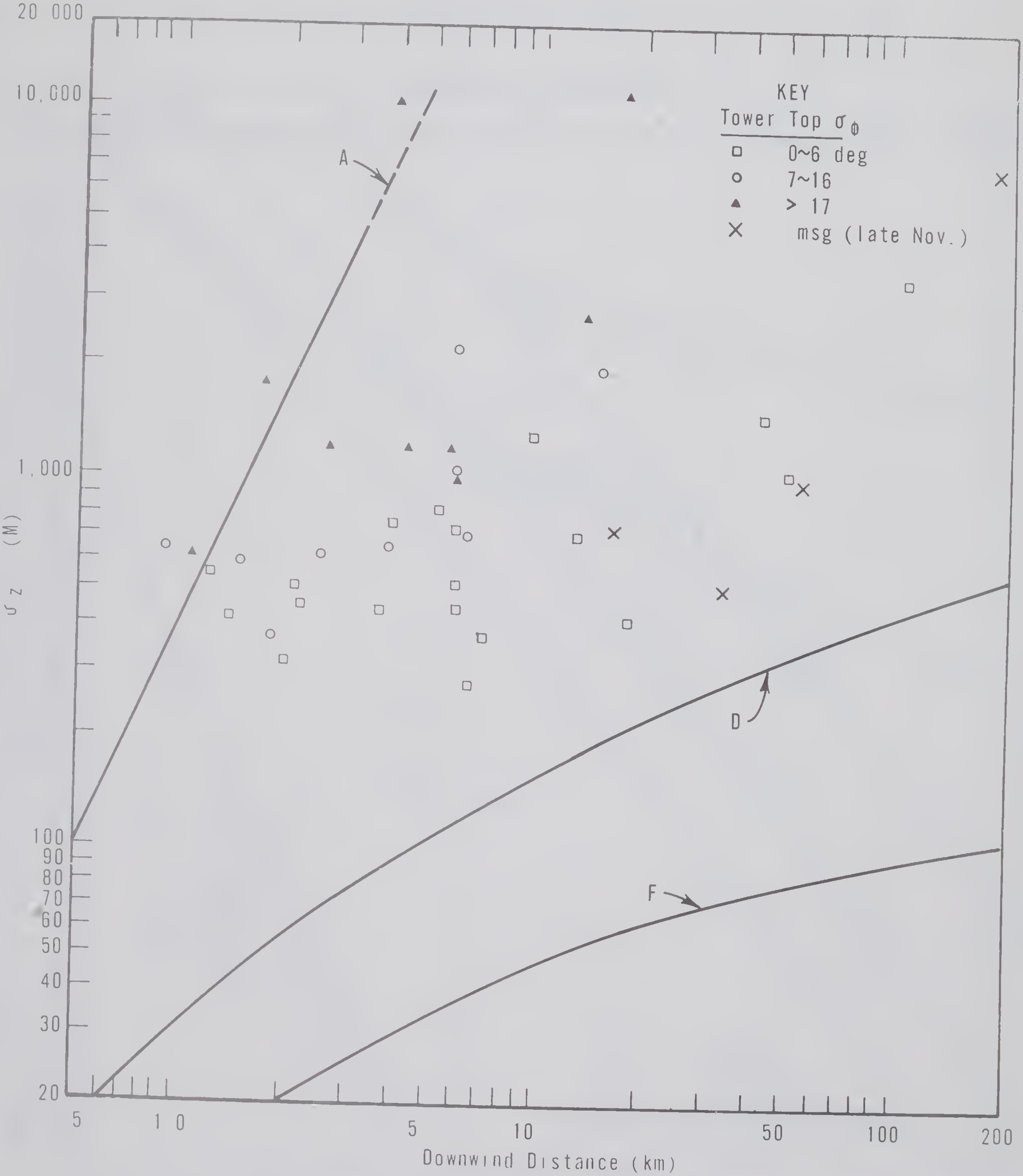
Extreme Plume Widths (Left Ordinate) as a Function of Downwind Distance. The Right Ordinate gives a Scale for Converting these Widths to Horizontal Standard Deviations in Meters.

FIGURE 11-3



Vertical Standard Deviation versus Downwind Distance. The Points have been Stratified by Three Classes of 300 ft. Wind Direction Range.

FIGURE 11-4



Vertical Standard Deviation versus Downwind Distance. The Points have been Stratified by Three Classes of Vertical Wind Direction Standard Deviation, σ_ϕ

FIGURE 11-5

strip will tend to promote lower ground level concentrations than those occurring in more uniform terrain conditions, as pollutants will be dispersed over a wider horizontal area. However, this effect may be offset by the increased vertical dispersion which will tend to mix the plume rapidly to the ground.

1. Long Term Model

The computer program of the long term model which was used to predict seasonal and annual pollutant concentrations was provided to the Air Quality Bureau of HES by the Environmental Protection Agency./11 This program is a modification of a program similar to that described by Martin (1971). The significant changes include provisions for the consideration of elevated terrain under stable conditions (Pasquill Classes E and F) and an output printout which lists concentrations at seven distances along the sixteen radial transects corresponding to the sixteen common wind directions.

The long term model does not calculate plume centerline concentrations; rather it computes concentrations averaged over a $22\frac{1}{2}°$ sector centered on one of the sixteen radial transects. This approach is based upon the assumption that over long periods wind directions will be distributed randomly within a given $22\frac{1}{2}°$ sector so that the horizontal distribution of the pollutant within that sector will be uniform. The basic equations of the long term model are given in Appendix A9.

Other basic assumptions and details of the long term model as applied to Colstrip, besides the general assumptions of the Gaussian model previously stated, include:

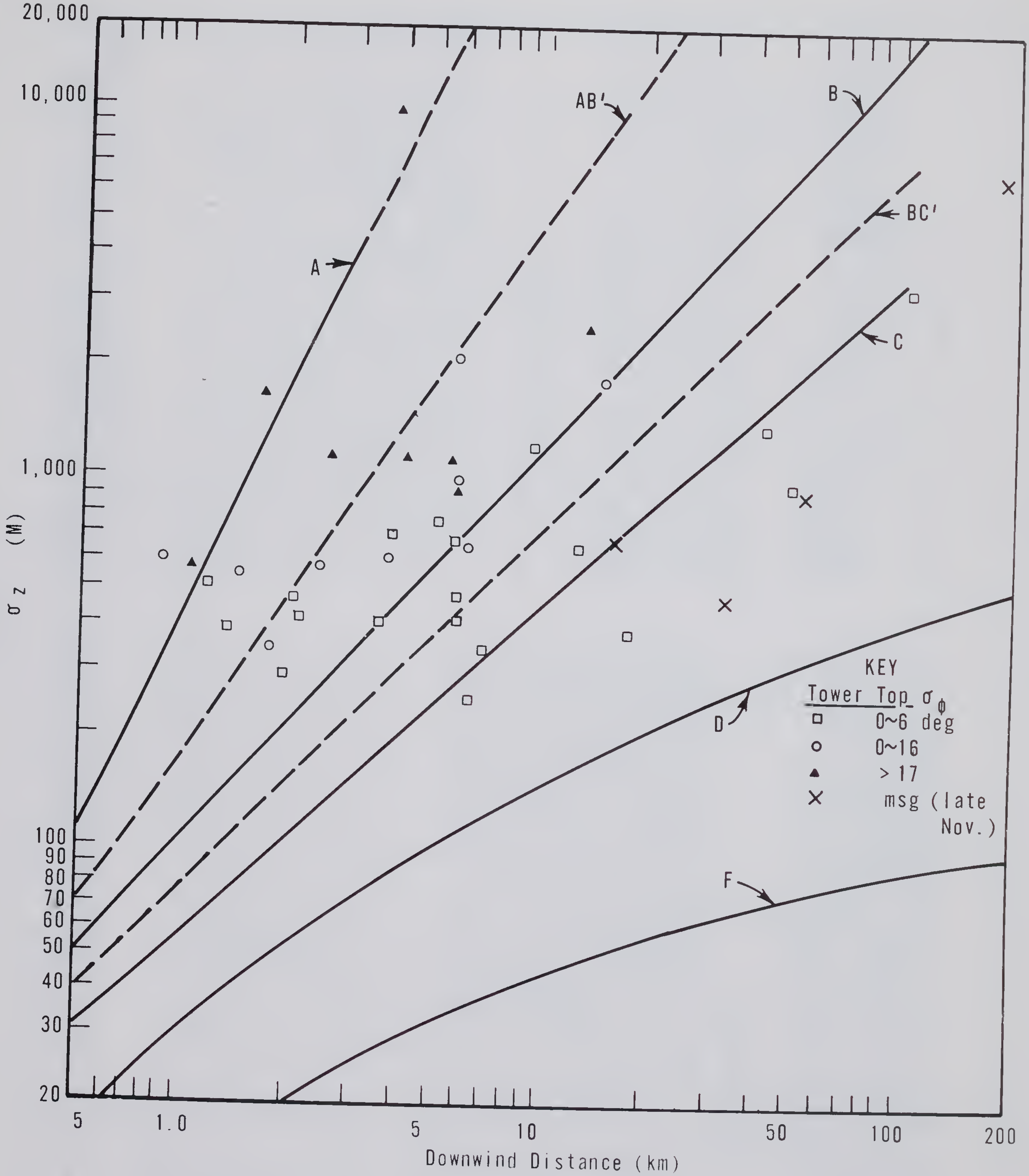
1. Pollutant concentrations are corrected from average Colstrip conditions (Temperature = 279°K, Standard Atmospheric Pressure = 900 mb) to standard conditions of 1 atmosphere pressure and temperature of 298°K.

2. All stacks with the same emission parameters, including stack height, stack diameter, effluent exit velocity, and exit temperature, were treated as a single emission source with an emission rate equal to the sum of the individual stack emission rates. Thus Units 1 and 2 were treated as one source and Units 3 and 4 together were treated as a second source.

3. No terrain effects are considered for reasons discussed below.

The climatic data utilized by the program include: a mean maximum afternoon and a mean minimum nighttime mixing depth; and the frequency of occurrence of six wind speed categories, sixteen wind directions, and six Pasquill vertical stability classes. The seasonal and annual wind frequency data and the mean maximum afternoon mixing data resulting from the data collection at Colstrip by Super et al., 1973 shown in Figures 10-1 and 10-7 in Section 10.1.1. were the specific data input to the program. As mean minimum nighttime data for Colstrip were not available, the program value of 200 meters (m) was used.

Figure 11-6 is a plot of the vertical dispersion coefficients, σ_z, versus downwind distance resulting from the ice nuclei (AgI) plume tracer experiments conducted by MSU. The



Vertical Standard Deviation versus Downwind Distance. The Points have been Stratified by Three Classes of Vertical Wind Direction Standard Deviation, σ_ϕ

FIGURE 11-6

preliminary data analysis by MSU did not successfully stratify the vertical dispersion coefficients versus meteorological parameters measured at Colstrip. The data also indicate that values of the vertical dispersion coefficient corresponding to the stable Pasquill curves E and F as given in Turner (1970) were not detected during the plume tracing study./12

For these reasons the following method was applied to obtain the stability class frequency data necessary to apply the long term model. The traditional Pasquill class A, B, and C curves were plotted along with the individual vertical standard deviation values. Lines bisecting the angles formed by the intersection of lines A and B and lines B and C were then plotted. The bisecting lines are the dotted ones in Figure 11-6. All points lying above dotted line AB' were associated with stability class A; all points between AB' and BC' were associated with class B, while all points below line BC' were assigned to class C. This classification scheme resulted in approximately 50% of the points being assigned to class B and approximately 25% being assigned to classes A and C. Thus the frequency of occurrence of the Pasquill stability classes input to the long term model was: A, 25%; B, 50%; C, 25%; D, E, and F, 0%.

a. Long Term Model Results

The predictions of the long term model for the annual and seasonal concentrations of SO_2 resulting from the proposed operation of Units 1 through 4 are shown in Figures 11-7 through 11-11 and corresponding maps. Figures 11-7 through 11-11 show the maximum SO_2 concentrations predicted within an approximate 15 kilometer radius of the plant site while the corresponding annual and seasonal maps show SO_2 concentration predictions over the entire study area. The maximum annual SO_2 concentration predicted was about 30 ug/m^3 or about .01 ppm assuming standard conditions./13 This value is one half of the Montana annual standard (0.2 ppm) and about one third of the federal annual standard (80 ug/m^3 or .03 ppm). Winter had the maximum seasonal SO_2 concentration of 91 ug/m^3 or .03 ppm while spring had the lowest seasonal maximum, 30 ug/m^3 or about .01 ppm. No seasonal ambient air standards exist.

Figures 11-7 through 11-11 can be converted to isopleths of any other pollutant by multiplying the SO_2 concentration by the ratio of the emission rate of the given pollutant to the emission rate of SO_2. For NO_2 and suspended particulate the ratios are .67 and .05, respectively. Table 11-4 contains the maximum annual values of SO_2, NO_2, total suspended particulate and fluoride.

b. Long Term Model Accuracy

Because no emission sources comparable to the proposed units currently exist in the immediate Colstrip area, model predictions cannot be directly compared with actual field data. Thus a verified quantitative assessment of the long term model accuracy cannot be made. Neglecting any error in plume rise estimates and the horizontal and vertical dispersion coefficient data, the assumptions of constant wind direction sector with distance, no pollutant reactivity, and no particulate gravitational settling or other removal processes will tend to make the predicted average concentrations somewhat higher than the actual ground level concentrations which will

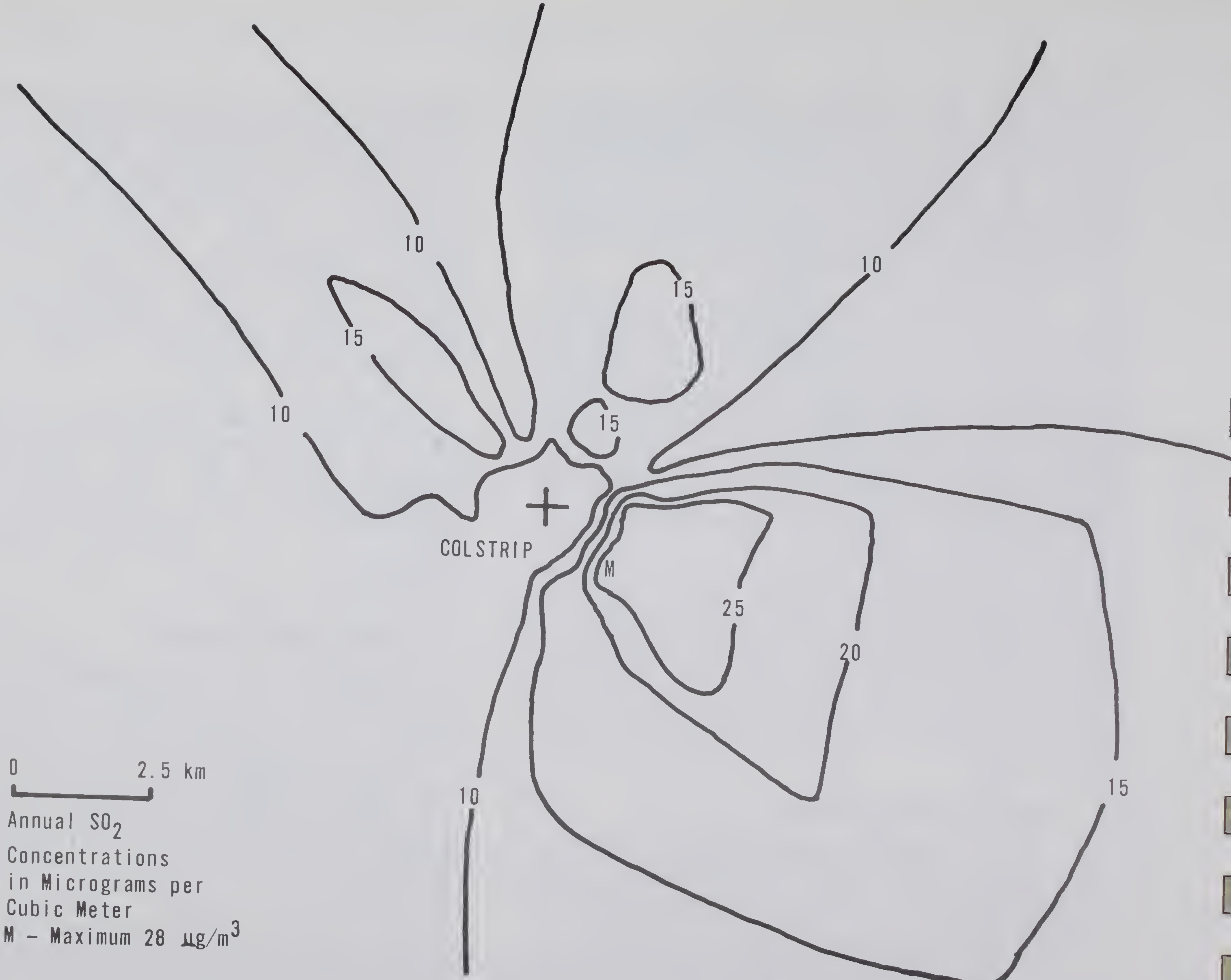
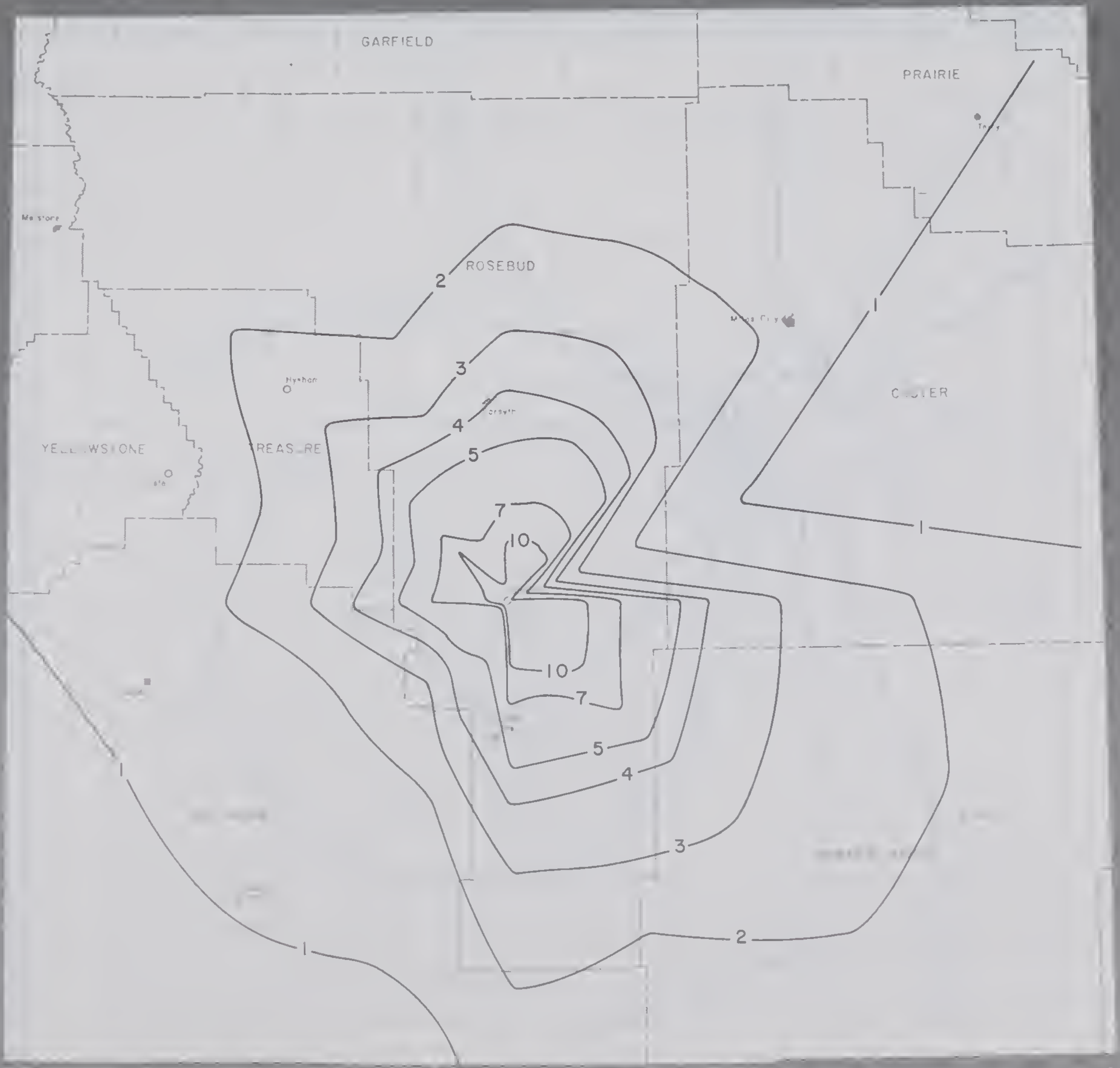

10
10
15
15
15
10
COLSTRIP
M
25
20
15
10
0
2.5 km
Annual SO_2 Concentrations in Micrograms per Cubic Meter
M – Maximum 28 µg/m^3

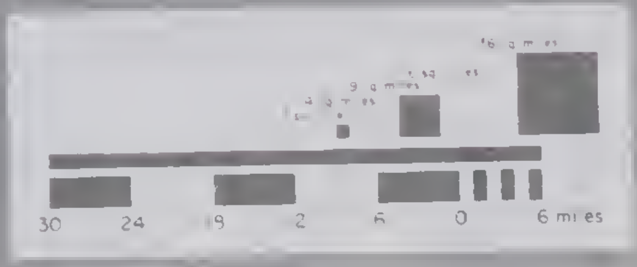
FIGURE 11-7

SO_2 CONCENTRATIONS

ANNUAL

—5— Isopleths in Micrograms per Cubic Meter





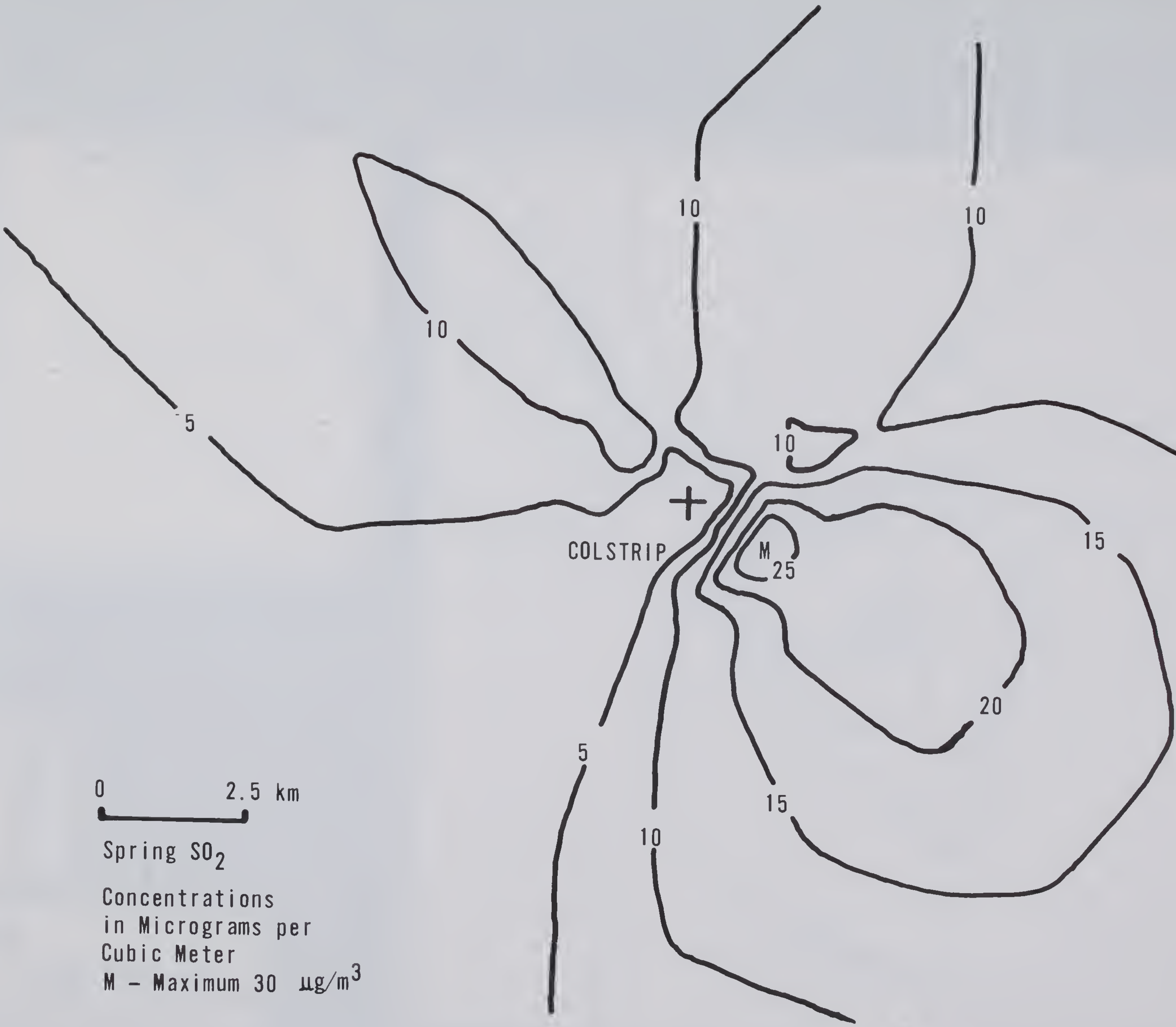
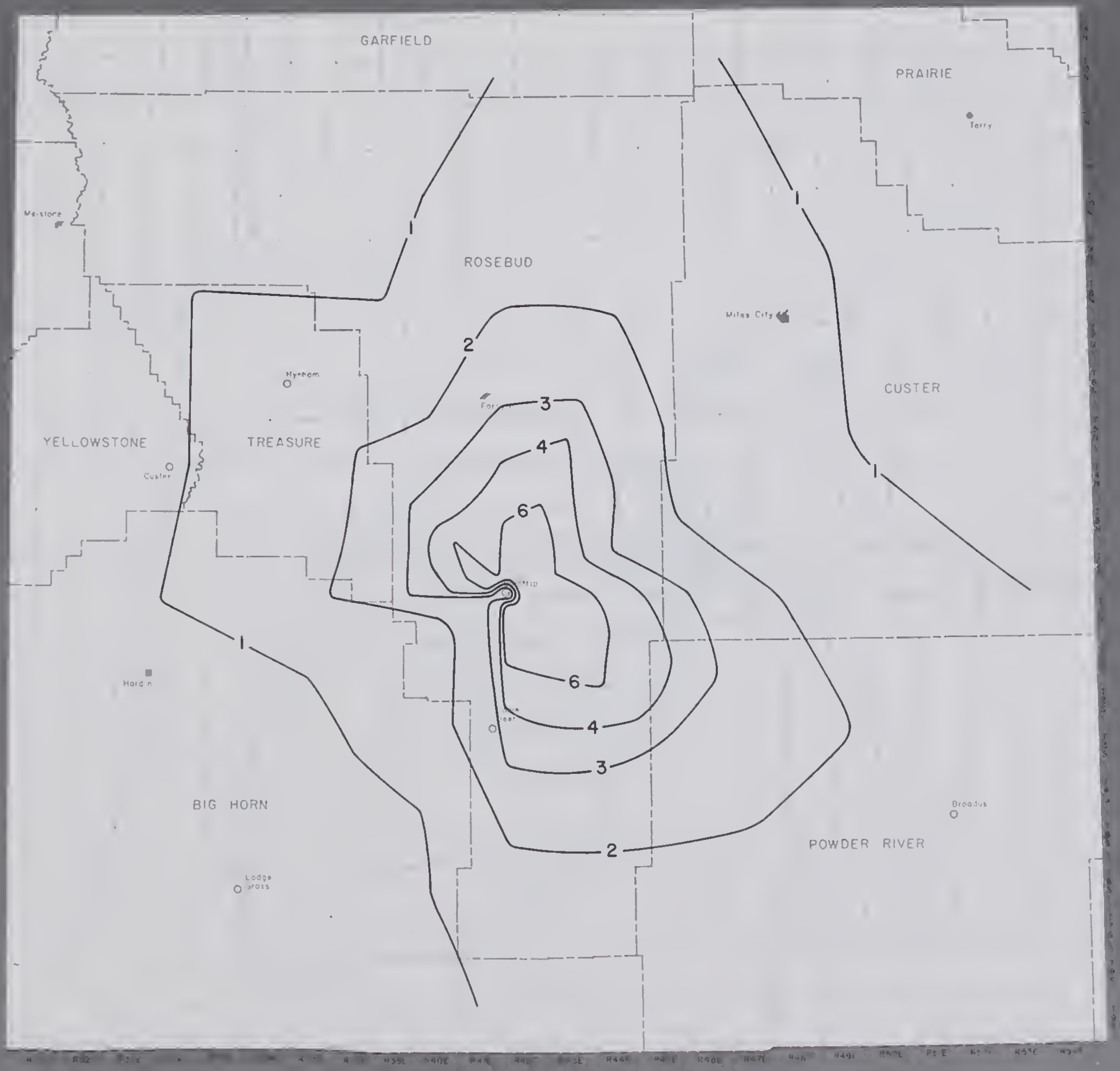
10
10
10
5
10
10
COLSTRIP
M
25
15
20
5
15
10
0
2.5 km
Spring SO2
Concentrations in Micrograms per Cubic Meter
M – Maximum 30 µg/m3

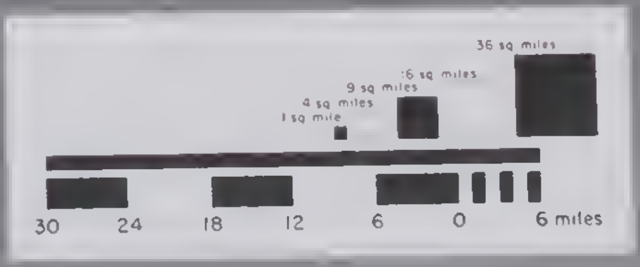
FIGURE 11-8



SO$_2$ CONCENTRATIONS

SPRING

—3— Isopleths in Micrograms per Cubic Meter



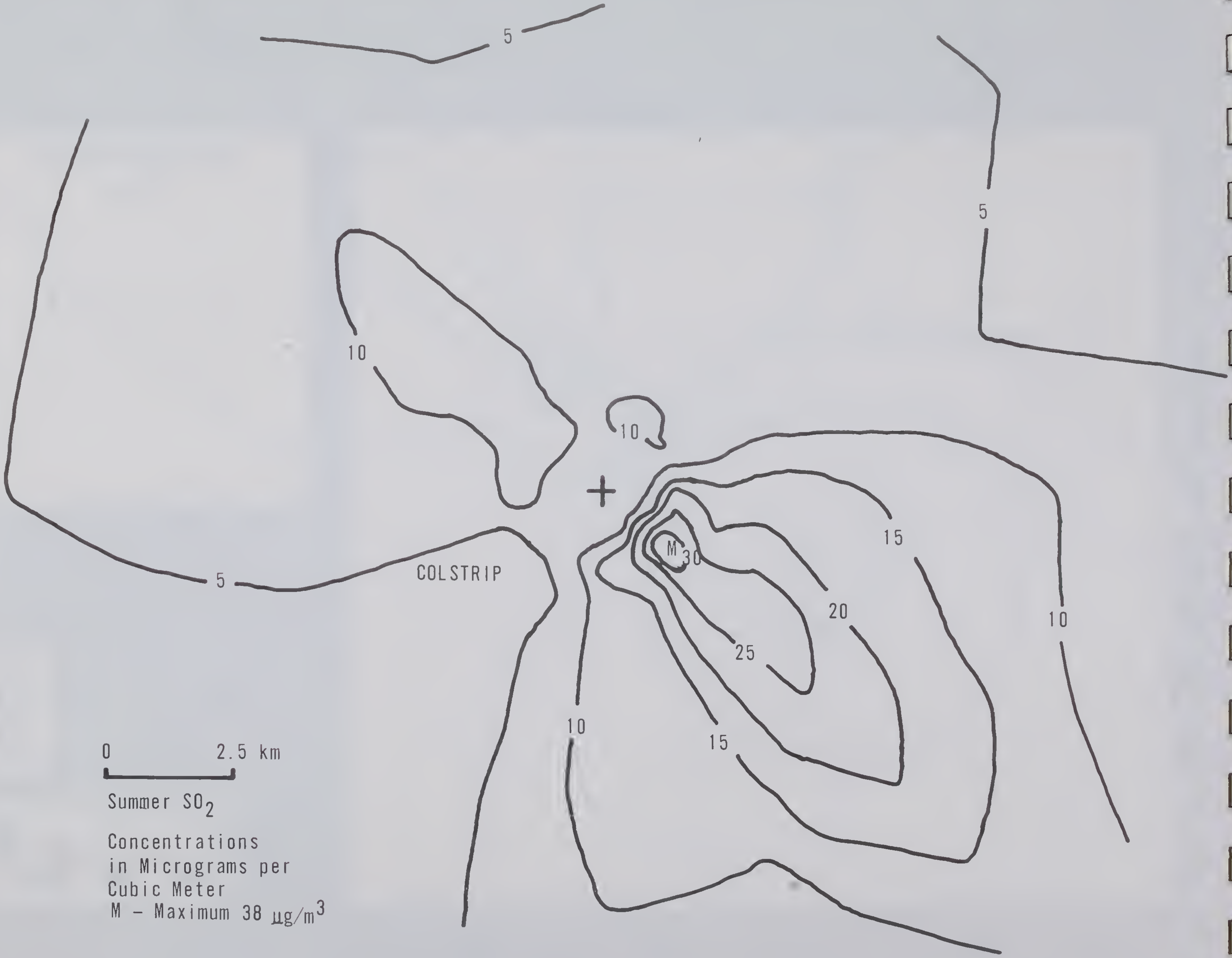
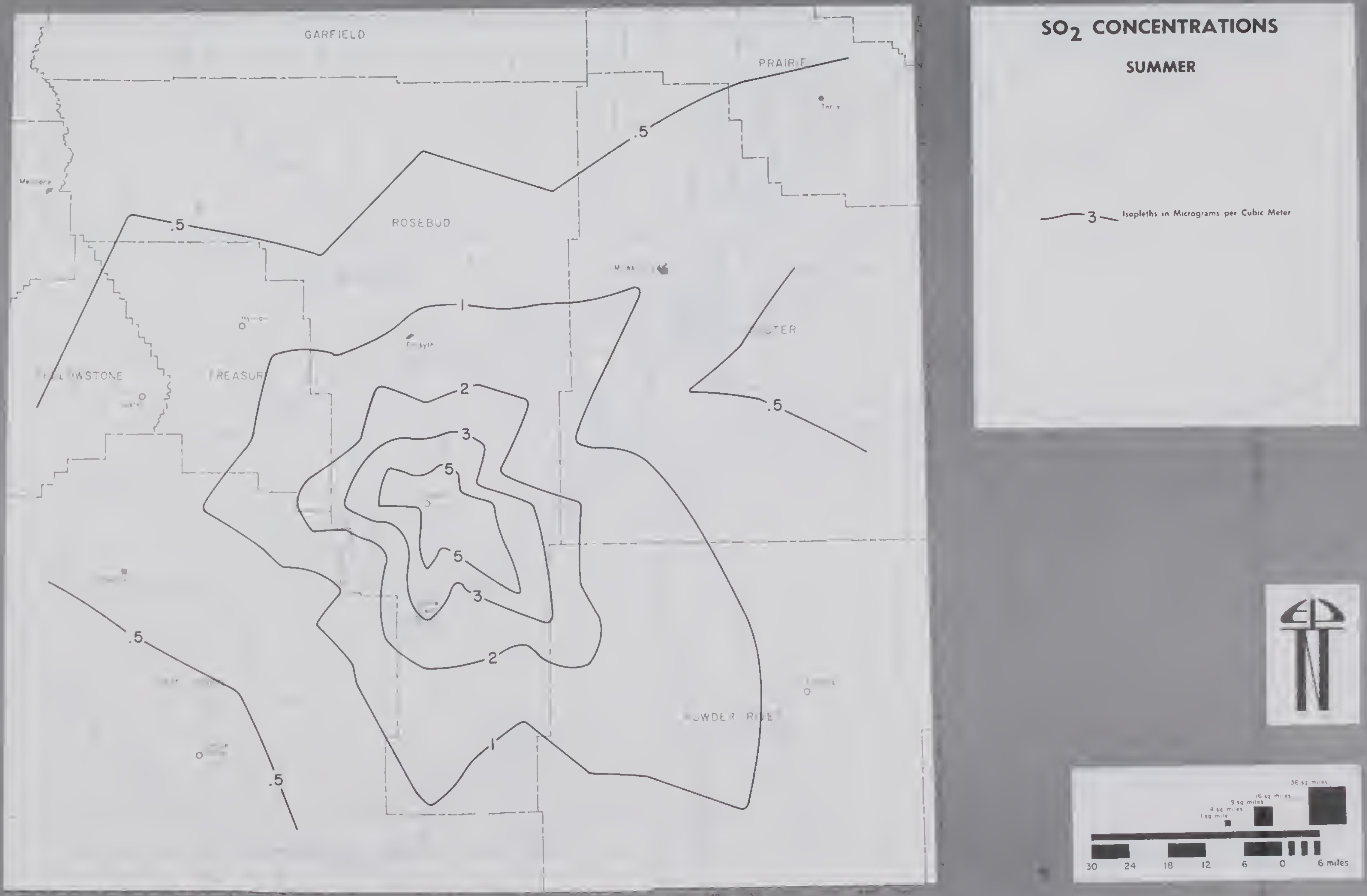

5
5
10
10
+
COLSTRIP
5
M 30
15
20
25
10
10
15
0
2.5 km
Summer SO_2
Concentrations
in Micrograms per
Cubic Meter
M – Maximum 38 μg/m^3

FIGURE 11-9

SO_2 CONCENTRATIONS

SUMMER



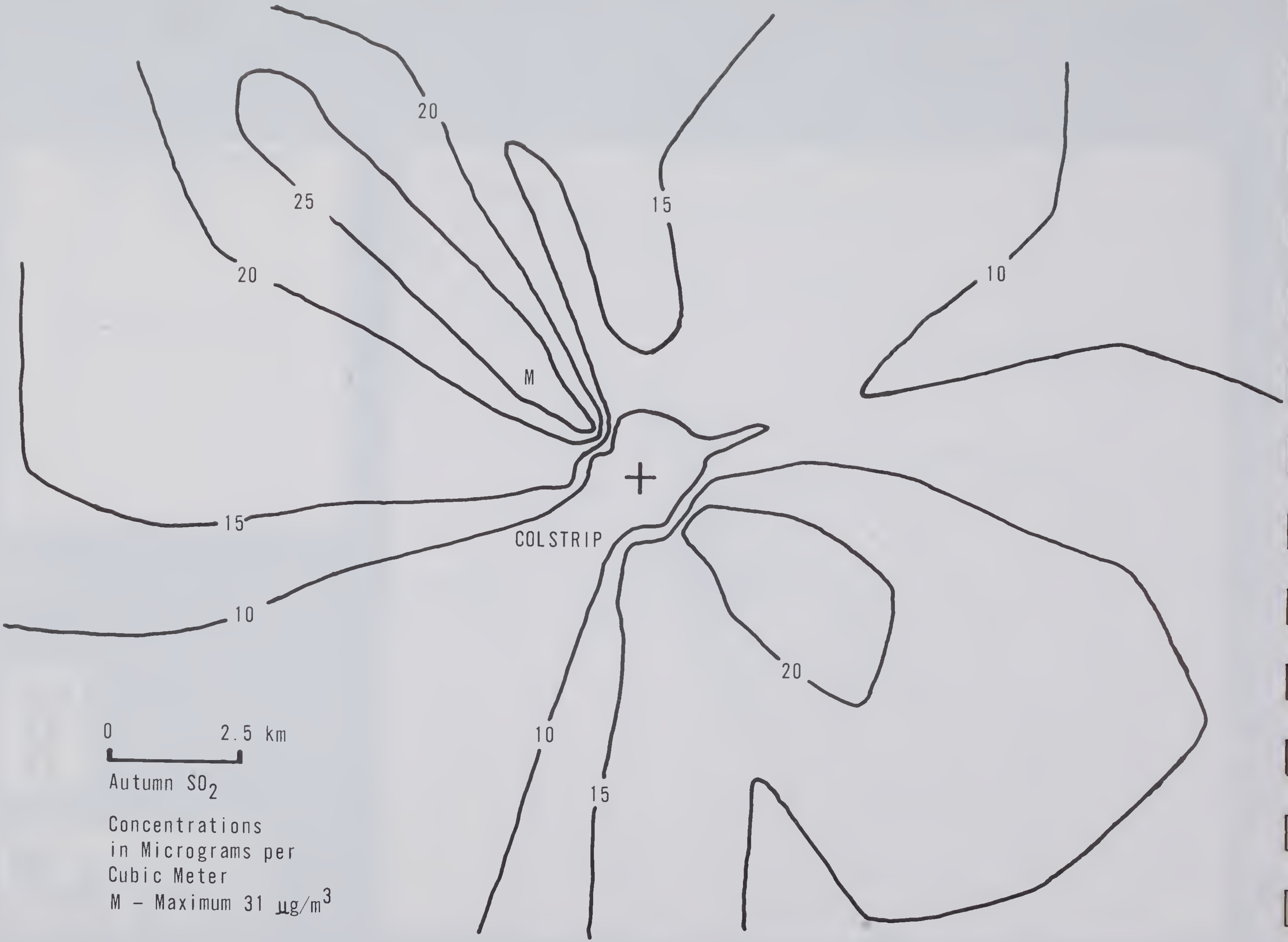
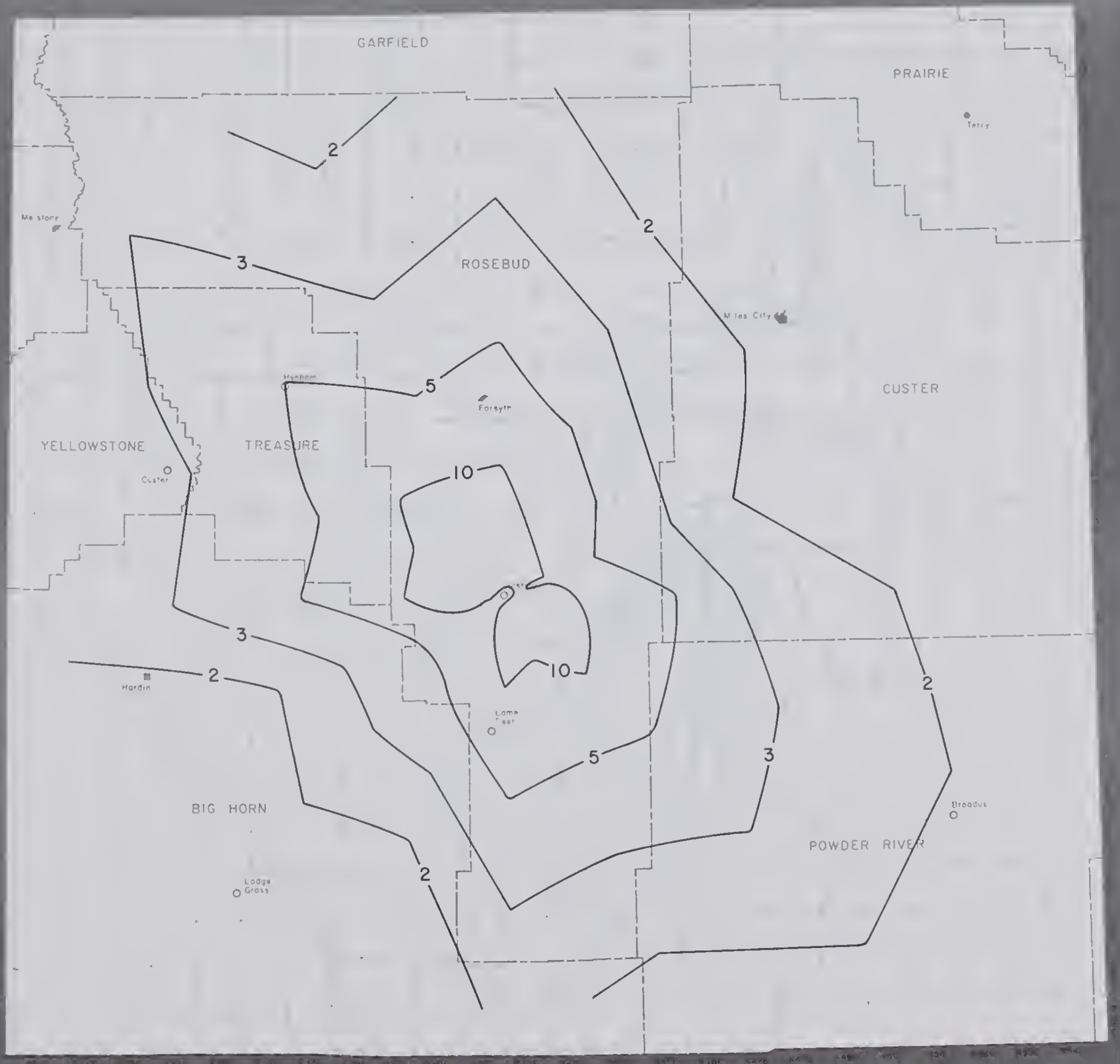

20
25
20
M
15
15
10
COLSTRIP
10
20
10
15
0
2.5 km
Autumn SO_2
Concentrations in Micrograms per Cubic Meter
M – Maximum 31 $\mu g/m^3$

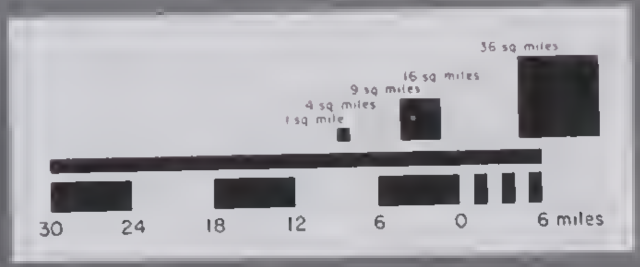
FIGURE 11-10

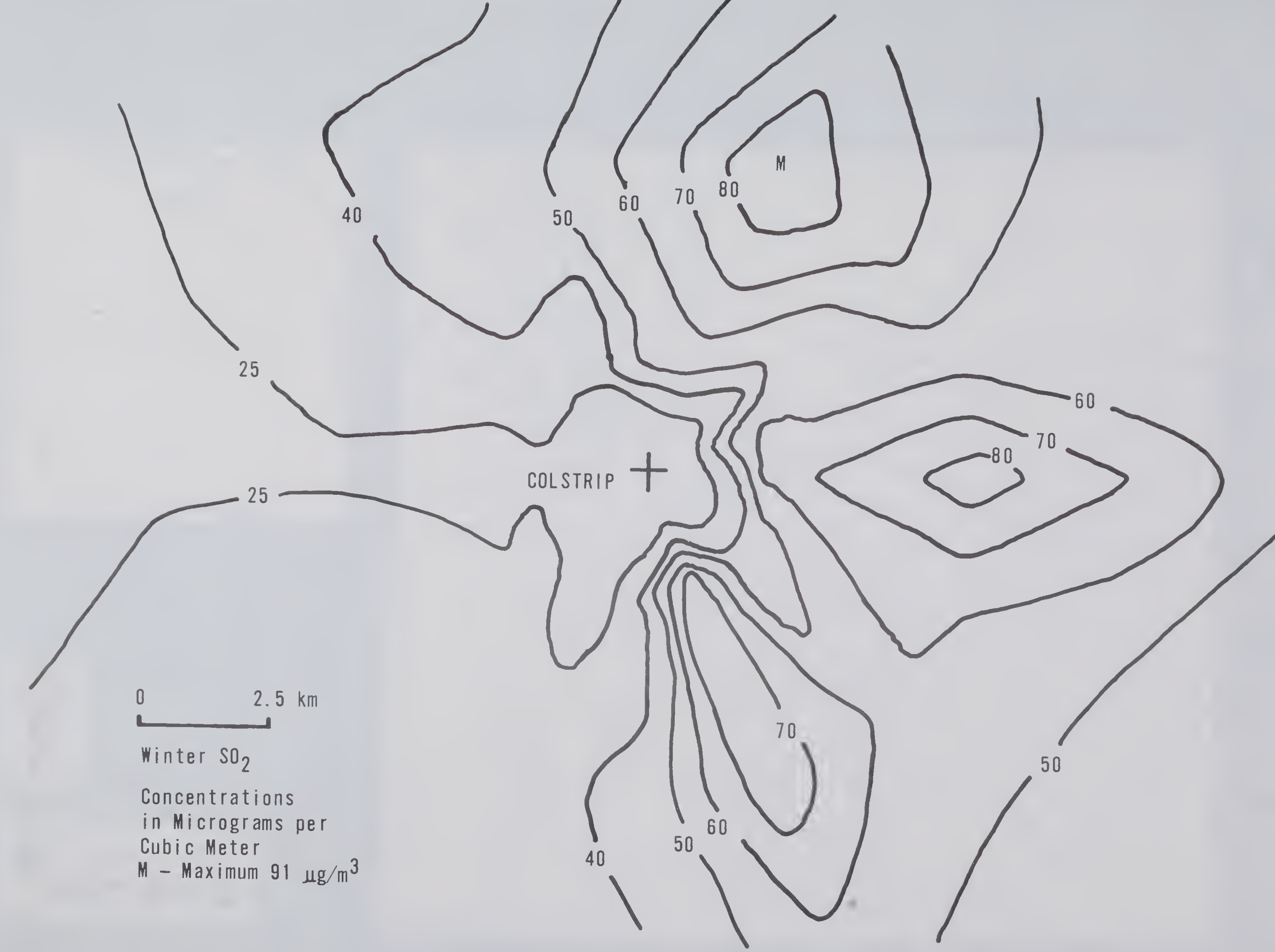


SO$_2$ CONCENTRATIONS

AUTUMN

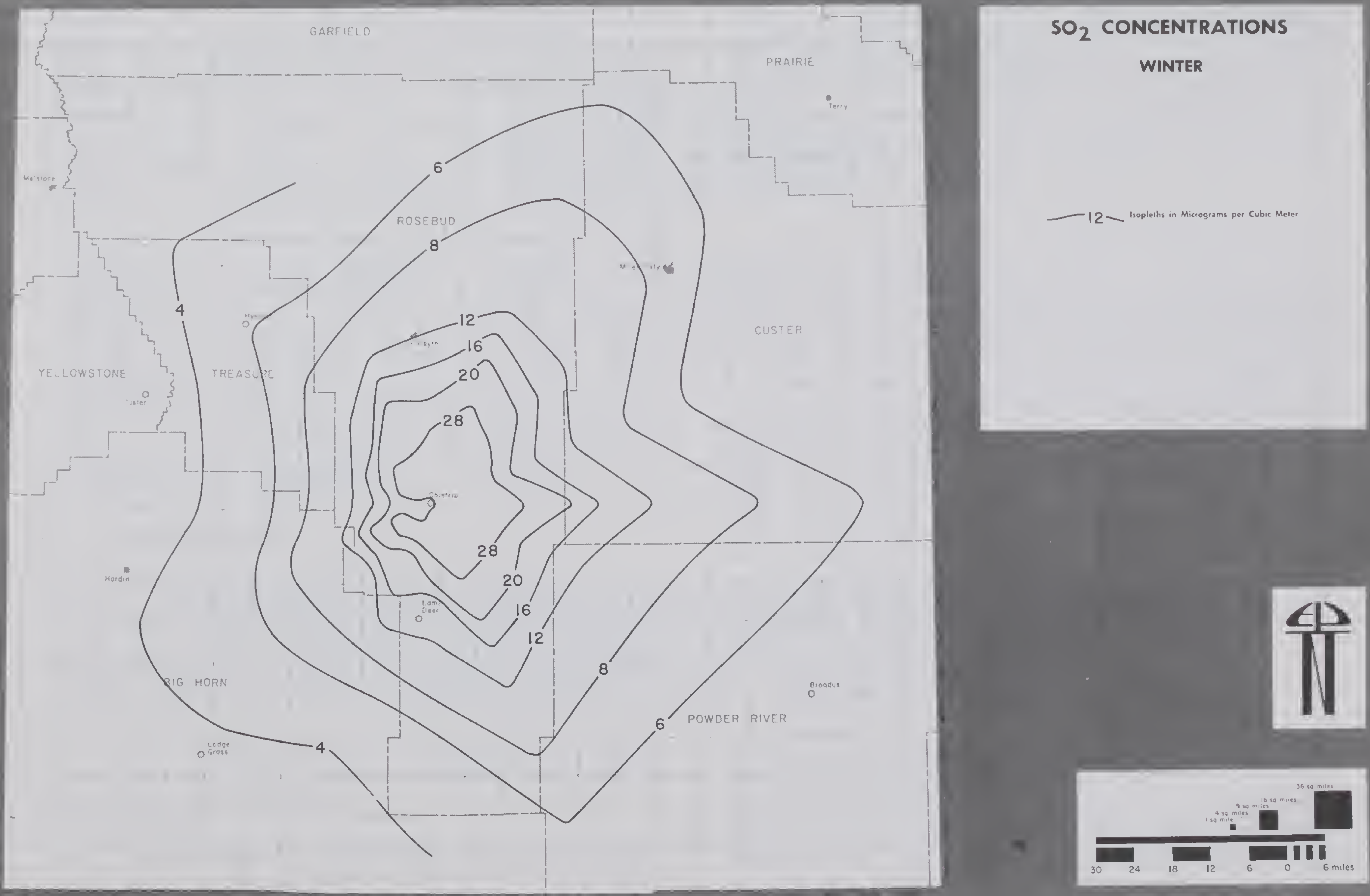
—5— Isopleths in Micrograms per Cubic Meter





40
50
60
70
80
M
25
60
70
80
COLSTRIP
25
0
2.5 km
70
50
40
50
60
Winter SO_2
Concentrations
in Micrograms per
Cubic Meter
M – Maximum 91 µg/m^3

FIGURE 11-11



SO_2 CONCENTRATIONS

WINTER

—12— Isopleths in Micrograms per Cubic Meter

TABLE 11-4

MAXIMUM ANNUAL AND SEASONAL CONCENTRATIONS IN $\mu g/m^3$

	Annual	Spring	Summer	Autumn	Winter
SO_2	28	30	38	31	91
NO_2	19	20	26	21	61
Particulates	1.4	1.5	1.9	1.6	4.7
Flourides	9×10^{-3}	9×10^{-3}	12×10^{-3}	10×10^{-3}	28×10^{-3}

Assuming a worst case approach in which all emitted flourides would be gaseous hydrogen flouride (HF), for conditions of 1 atm pressure and 298°k temperature the above flouride concentrations in ppb (parts per billion) are: Annual, .01 ppb; spring, .01 ppb; summer .01, ppb; autumn, .01 ppb; and winter, .03 ppb.

result from the proposed emissions. For distances up to about five kilometers (km) downwind of the stack, pollutant transit times will be about 15 minutes or less, assuming the mean annual wind speed of 5.4 m/sec. Thus the time period available for pollutant reactions will be relatively short. Also, the 0.5 to 5 km downwind range contains about 60% of the vertical dispersion data points resulting from the plume tracer study. This indicates that the coefficients should be reliable in this range. For these two reasons, for distances up to about five km the predicted concentrations may be assumed to be within an order of magnitude of the actual values. As downwind distance to the receptor is increased pollutant transit time is also increased; therefore the likelihood of significant changes in atmospheric conditions from those existing at the stack when the pollutants were initially released is enhanced and the possibility of pollutant reactions is increased. The model accuracy will therefore decrease with increasing downwind distance.

2. Short Term Model

The Gaussian model used to estimate pollutant concentrations for the short term, from one-half hour to twenty-four hours, is based on equations given by Turner (1970) and Briggs (1969). Details of the equations used for the short term predictions are given in Appendix A10.

The assumptions and details of the short term modeling are similar to those explained in the long term modeling.

As previously mentioned, the preliminary analysis of the ice nuclei plume tracing data by MSU indicated both horizontal and vertical plume widths at Colstrip to be greater than those expected from the Pasquill dispersion curves found in Turner (1970). Also, the preliminary analysis was not able to satisfactorily stratify the calculated plume dispersion coefficients as a function of the meteorological parameters measured at Colstrip. Such a stratification is necessary to predict the frequency of occurrence of any given pair of horizontal and vertical dispersion coefficients.

In the absence of this stratification the following approach was used to select the dispersion coefficients demanded by the model. Four lines were drawn on the plots of the horizontal and the vertical dispersion coefficients supplied by MSU. Two of the lines in each case were drawn to bound the data points and represent the maximum unstable and stable conditions. The two additional lines were drawn to represent more moderate stability conditions. These lines together with the plotted dispersion coefficient data are shown in Figures 11-12 and 11-13. For a given wind speed and mixing depth, calculations of ground level pollutant concentrations were made using the sixteen possible combinations of the four horizontal and four vertical lines of dispersion coefficients versus distance.

a. Short Term Model Results

Tables 11-5 and 11-6 list the results of such calculations of SO_2 for the following meteorological conditions: wind speed of 5.4 m/sec (the mean annual 307 ft. wind speed at Colstrip) and mixing depths of 10,000 meters and 600 meters; and a wind speed of two meters per second and mixing depths of 10,000 and 1300m. The 10,000

TABLE 11-5: SHORT-TERM MODEL SO_2 RESULTS ($p = .2$)

Wind Speed (m/sec)	Mixing Depth (m)	σ_y	σ_z^*	Calculation Distance Range (km)	Calculation Distance Interval (km)	Distance (km)	Maximum Concentration ½hr (ug/m³)	Maximum Concentration 1hr (ug/m³)	Maximum Concentration 3hr (ug/m³)	Maximum Concentration 24hr (ug/m³)
5.4	10,000	1	1	0-1	0.1	0.5	695	605	486	320
		1	2	0-2	0.1	0.7	377	329	263	174
		1	3	0-2	0.1	0.9	93	81	57	43
		1	4	0-50	5	15	38	33	26	18
		2	1	0-1	0.1	0.5	2710	2359	1894	1250
		2	2	0-1.5	0.1	0.7	1325	1153	925	611
		2	3	0-2	0.1	0.7	315	274	220	145
		2	4	0-50	5	10	78	67	55	36
		3	1	0-1	0.1	0.5	7744	6742	5412	3570
		3	2	0-1.5	0.1	0.7	3784	3294	2644	1745
		3	3	0-2	0.1	0.7	901	784	629	415
		3	4	0-50	5	10	222	194	155	102
		4	1	0-1	0.1	0.5	15,489	13,483	10,823	7142
		4	2	0-1.5	0.1	0.7	7569	6588	5289	3489
		4	3	0-1.5	0.1	0.7	1802	1569	1259	830
		4	4	0-50	5	10	445	387	311	205
5.4	600	1	1	0-2	0.1	0.5	723	629	439	333
		1	2	0-2	0.1	0.7	377	329	230	174
		1	3	0-5	0.1	4	214	188	131	99
		1	4	0-20	1	17	74	64	52	24
		2	1	0-2	0.1	0.5	2710	2359	1894	1250
		2	2	0-2	0.1	0.7	1325	1153	806	611
		2	3	0-10	0.5	4	530	462	322	244
		2	4	0-20	1	17	146	128	102	72

*The designation 1,2,3 or 4 for σ_y and σ_z refers to the lines in Figures 11-12 and 11-13 labeled σ_{y1}, σ_{y2}, ...,σ_{z1}, σ_{z2}, ..., used to calculate σ_y or σ_z.

TABLE 11-5 (cont.)

Wind Speed (m/sec)	Mixing Depth (m)	σ_y	σ_z*	Calculation Distance Range (km)	Calculation Distance Interval (km)	Distance (km)	Maximum Concentration ½hr (ug/m³)	1hr (ug/m³)	3hr (ug/m³)	24hr (ug/m³)
5.4	600	3	1	0-2	0.1	.5	7744	6742	5412	3570
		3	2	0-2	0.1	.7	3785	3295	2645	1745
		3	3	0-5	0.5	4	1513	1317	1058	698
		3	4	0-20	1	17	419	365	293	193
		4	1	0-2	0.1	.5	15,489	13,483	10,823	7142
		4	2	0-2	0.1	.7	7569	6589	5480	3490
		4	3	0-5	0.5	4	3028	2636	2116	1396
		4	4	0-20	1	17	838	729	586	387
2	10,000	1	1	0-10	0.5	1	465	405	325	214
		1	2	0-10	0.5	2.5	180	157	125	83
		1	3	0-20	0.5	10.5	63	55	44	30
		1	4	0-90	5	85	13	11	8	6
		2	1	0-10	0.5	1	1516	1320	1060	699
		2	2	0-10	0.5	2.5	489	426	341	226
		2	3	0-10	0.5	9	132	115	92	61
		2	4	0-80	5	70	17	15	12	7
		3	1	0-10	0.5	1	4333	3773	3029	1998
		3	2	0-10	0.5	2.5	1397	1216	977	644
		3	3	0-10	0.5	9	376	328	174	174
		3	4	0-80	5	70	48	42	34	22
		4	1	0-10	0.5	1	8666	7534	6056	3996
		4	2	0-10	0.5	2.5	2795			
		4	3	0-10	0.5	9	752	655	526	347
		4	4	0-80	5	70	97	84	67	44

*The designation 1,2,3 or 4 for σ_y and σ_z refers to the lines in Figures 11-12 and 11-13 labeled σ_{y1}, σ_{y2}, ..., σ_{z1}, σ_{z2}, ..., used to calculate σ_y or σ_z.

TABLE 11-5 (cont.)

Wind Speed (m/sec)	Mixing Depth (m)	σ_y	σ_z*	Calculation Distance Range (km)	Calculation Distance Interval (km)	Distance (km)	Maximum Concentration ½hr (ug/m^3)	Maximum Concentration 1hr (ug/m^3)	Maximum Concentration 3hr (ug/m^3)	Maximum Concentration 24hr (ug/m^3)
2	1300	1	1	0-10	0.5	1	585	509	409	270
		1	2	0-10	0.5	3.5	291	253	203	134
		1	3	5-18	0.5	13	119	103	83	55
		1	4	40-130	10	120	26	23	18	13
		2	1	0-10	0.5	1	1944	1692	1358	897
		2	2	0-10	0.5	3.5	740	644	517	341
		2	3	11-15	0.5	13	234	203	163	107
		2	4	40-130	10	120	33	28	23	15
		3	1	0-10	0.5	1	5557	4837	3883	2562
		3	2	0-10	0.5	3.5	2114	1840	1477	975
		3	3	11-15	0.5	13	667	581	466	308
		3	4	40-130	10	120	95	82	66	43
		4	1	0-10	0.5	1	11,112	9674	7765	5124
		4	2	0-10	0.5	3.5	4227	3680	2954	1948
		4	3	11-15	0.5	13	1334	1161	933	615
		4	4	40-130	10	120	189	164	133	87

*The designation 1,2,3 or 4 for σ_y and σ_z refers to the lines in Figures 11-12 and 11-13 labeled σ_{y1}, σ_{y2}, ..., σ_{z1}, σ_{z2} , ..., used to calculate σ_y or σ_z.

TABLE 11-6: SHORT-TERM MODEL SO_2 RESULTS (p = .44)

Wind Speed (m/sec)	Mixing Depth (m)	σ_y	σ_z*	Calculation Distance Range (km)	Calculation Distance Interval (km)	Distance (km)	Maximum Concentration ½hr (ug/m^3)	Maximum Concentration 1hr (ug/m^3)	Maximum Concentration 3hr (ug/m^3)	Maximum Concentration 24hr (ug/m^3)
5.4	10,000	1	1	0-1	0.1	0.5	695	512	316	126
		1	2	0-2	0.1	0.7	377	278	172	68
		1	3	0-2	0.1	0.9	93	68	42	17
		1	4	0-50	5	15	38	28	17	7
		2	1	0-1	0.1	0.5	2710	1998	1232	493
		2	2	0-15	0.1	0.7	1325	977	602	241
		2	3	0-2	0.1	0.7	315	232	143	57
		2	4	0-50	5	10	78	58	36	14
		3	1	0-1	0.1	0.5	7744	5708	3521	1410
		3	2	0-1.5	0.1	0.7	3784	2789	1720	689
		3	3	0-2	0.1	0.7	901	664	410	164
		3	4	0-50	5	10	222	164	101	40
		4	1	0-1	0.1	0.5	15,489	11,417	7040	2820
		4	2	0-1.5	0.1	0.7	7569	5580	3441	1378
		4	3	0-1.5	0.1	0.7	1802	1329	819	328
		4	4	0-50	5	10	445	328	202	81
5.4	600	1	1	0-2	0.1	0.5	723	533	329	132
		1	2	0-2	0.1	0.7	377	278	172	68
		1	3	0-5	0.1	4	214	158	97	39
		1	4	0-20	1	17	74	55	34	14
		2	1	0-2	0.1	0.5	2710	1998	1232	493
		2	2	0-2	0.1	0.7	1325	977	602	241
		2	3	0-10	0.5	4	530	391	241	97
		2	4	0-20	1	17	146	107	66	26

*The designation 1,2,3 or 4 for σ_y and σ_z refers to the line in Figures 10-12 and 10-13 labeled σ_{y1}, σ_{y2}, ..., σ_{z1}, σ_{z2}, ...used to calculate σ_y or σ_z.

TABLE 11-6 (cont.)

Wind Speed ($^m/sec$)	Mixing Depth (m)	σ_y	σ_z *	Calculation Distance		Distance (km)	Maximum Concentration			
				Range (km)	Interval (km)		½hr (ug/m^3)	1hr (ug/m^3)	3hr (ug/m^3)	24hr (ug/m^3)
5.4	600	3	1	0-2	0.1	.5	7744	5708	3520	1410
		3	2	0-2	0.1	.7	3785	2790	1721	689
		3	3	0-5	0.5	4	1513	1116	688	275
		3	4	0-20	1	17	419	309	191	76
		4	1	0-2	0.1	.5	15,489	11,417	7040	2820
		4	2	0-2	0.1	.7	7569	5580	3441	1378
		4	3	0-5	0.5	4	3028	2232	1376	551
		4	4	0-20	1	17	838	618	380	153
2	10,000	1	1	0-10	0.5	1	465	342	211	84
		1	2	0-10	0.5	2.5	180	133	82	33
		1	3	0-20	0.5	10.5	63	46	28	12
		1	4	0-90	5	85	13	9	5	2
		2	1	0-10	0.5	1	1516	1118	689	276
		2	2	0-10	0.5	2.5	489	360	222	89
		2	3	0-10	0.5	9	132	97	60	24
		2	4	0-80	5	70	17	13	7	3
		3	1	0-10	0.5	1	4333	3194	1970	789
		3	2	0-10	0.5	2.5	1397	1030	635	254
		3	3	0-10	0.5	9	376	277	171	68
		3	4	0-80	5	70	48	36	22	8
		4	1	0-10	0.5	1	8666	6388	3939	1578
		4	2	0-10	0.5	2.5	2795	2060	1271	509
		4	3	0-10	0.5	9	752	554	342	137
		4	4	0-80	5	70	97	72	44	18

*The designation 1,2,3 or 4 for σ_y and σ_z refers to the line in Figures 10-12 and 10-13 labeled σ_{y1}, σ_{y2}, ..., σ_{z1}, σ_{z2}, ...used to calculate σ_y or σ_z.

TABLE 11-6 (cont.)

Wind Speed (^{m}/sec)	Mixing Depth (m)	σ_y	σ_z*	Calculation Distance Range (km)	Calculation Distance Interval (km)	Distance (km)	Maximum Concentration ½hr (ug/m^3)	1hr (ug/m^3)	3hr (ug/m^3)	24hr (ug/m^3)
2	1300	1	1	0-10	0.5	1	585	431	266	106
		1	2	0-10	0.5	3.5	291	214	132	53
		1	3	5-18	0.5	13	119	87	54	22
		1	4	40-130	10	120	26	19	12	5
		2	1	0-10	0.5	1	1944	1433	884	354
		2	2	0-10	0.5	3.5	740	545	336	135
		2	3	11-15	0.5	13	234	173	106	42
		2	4	40-130	10	120	33	24	15	6
		3	1	0-10	0.5	1	5557	4096	2526	1012
		3	2	0-10	0.5	3.5	2114	1559	961	385
		3	3	11-15	0.5	13	667	492	303	121
		3	4	40-130	10	120	95	70	43	17
		4	1	0-10	0.5	1	11,112	8191	5052	2023
		4	2	0-10	0.5	3.5	4227	3116	1921	769
		4	3	11-15	0.5	13	1334	983	607	243
		4	4	40-130	10	120	189	139	85	35

For purposes of comparison, the Montana and Federal ambient air standards are given in Appendix A3. In units equivalent to those used in the preceding table the SO_2 standards are

	Annual	24 hour	3 hour	1 hour
Federal	80 ug/m^{3a}	365 ug/m^{3b}	1300 ug/m^{3b}	-
Montana	52 ug/m^{3a}	262 ug/m^{3c}	-	654 ug/m^{3d}

a. arithmetic mean

b. not to be exceeded more than once per year

c. not to be exceeded more than 1% of a three-month period

d. not to be exceeded more than once in four days.

*The designation 1,2,3 or 4 for σ_y and σ_z refers to the line in Figures 10-12 and 10-13 labeled σ_{y1}, σ_{y2}, ... σ_{z1}, σ_{z2}, ...used to calculate σ_y or σ_z.

meter mixing depth represented effectively unlimited mixing, while the 600 and 1300 meter values were chosen to illustrate plume trapping conditions./14

Because the horizontal and vertical dispersion coefficient data were reported to represent one-half hour averaging times by Heimbach, et al., (1974), calculations had to be made to convert the resultant one-half hour SO_2 concentrations to one hour, three hour, and twenty-four hour values to facilitate comparisons with existing state and federal standards. The equation suggested by Turner (1970) was used to make the conversion:

$$X_f = X_i\left(\frac{T_i}{T_f}\right)^p$$

Where X_f = concentration for period T_f (ug/m^3)

X_i = concentration for period T_i (ug/m^3)

T_f = period for which concentration is desired (hr)

T_i = period represented by dispersion coefficient data ($\frac{1}{2}$ hr)

p = an empirical constant

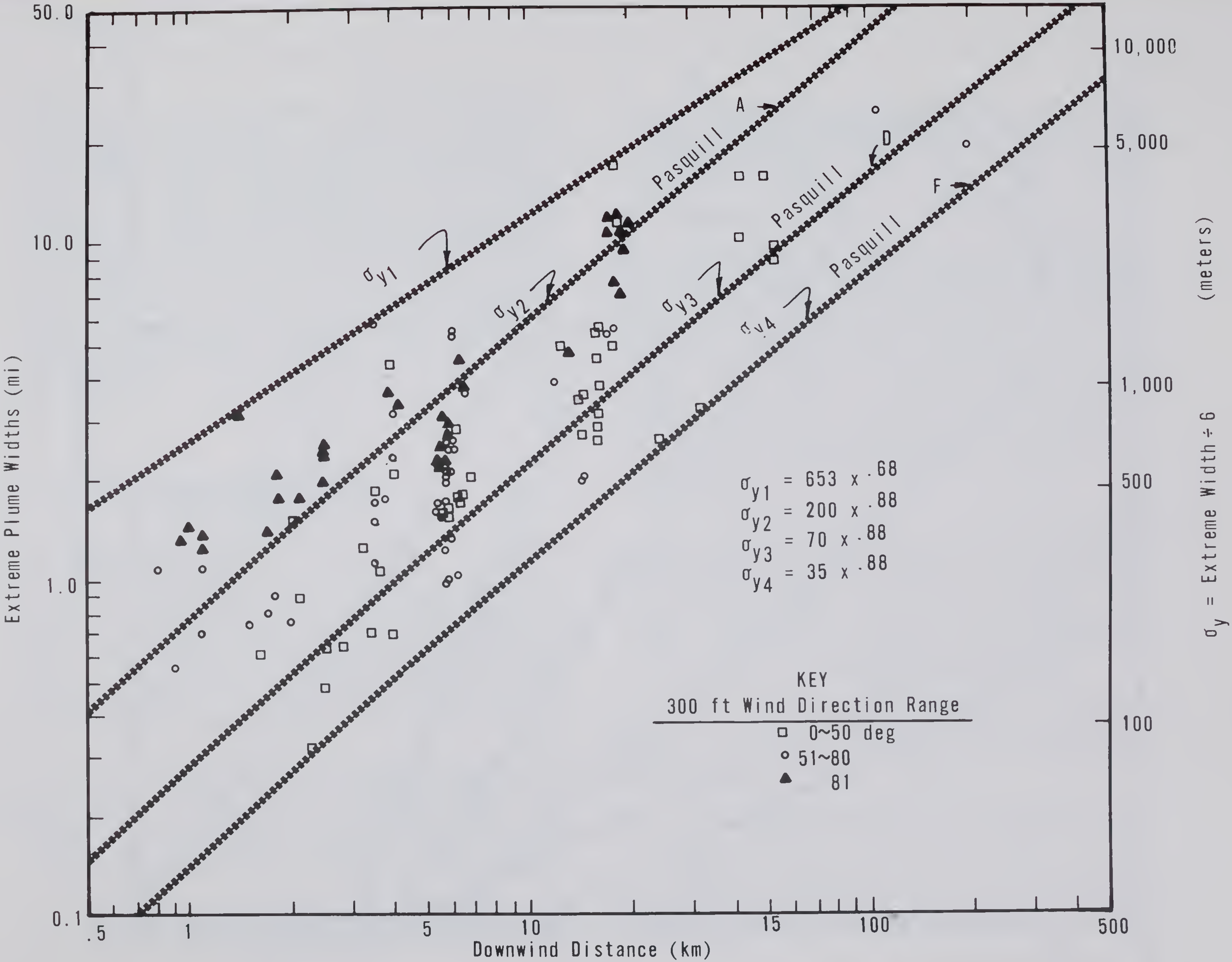
Different values have been reported for the constant p. Turner (1970) suggests 0.2, while Hino (1968) suggests 0.5. Based on the Helena Valley, Montana, Area Environmental Pollution Study (1972), the Northern Great Plains Resources Program (1974) suggested a value for p of 0.44. In Tables 11-5 and 11-6 the one hour, three hour, and twenty-four hour values were calculated two ways. Table 11-5 contains results for p = .2 and Table 11-6 contains results for p = .44.

A comparison of the predicted SO_2 concentrations listed in Table 11-5 and 11-6 with the state and federal ambient air standards listed in Appendix A3 indicates that several of the Table 11-5 and 11-6 concentrations exceed standards. The highest predicted concentrations were associated with the extreme stability conditions, lines 1 and 4 in Figures 11-12 and 11-13. However, concentrations corresponding only to the more moderate conditions, lines 2 and 3, also exceed the Montana one hour, the federal three hour, and the Montana and federal 24 hour standards in both Tables 11-5 and 11-6.

At this time the State does not possess enough information to conclude whether or not the Colstrip units will, in fact, violate the Montana one hour or 24-hour SO_2 standards. The critical information that is lacking is the frequency of occurrence of the predicted concentrations. This frequency will be predictable when the dispersion coefficient data shown in Figures 11-12 and 11-13 is stratified versus the meteorological parameters measured at Colstrip. Work is continuing at MSU to complete this stratification and to verify the preliminary dispersion coefficient data shown in Figures 11-2, 11-3, 11-4 and 11-5. Results should become available to the State prior to issuance of the final impact statement so that a decision with respect to compliance with the short term SO_2 standards can be incorporated.

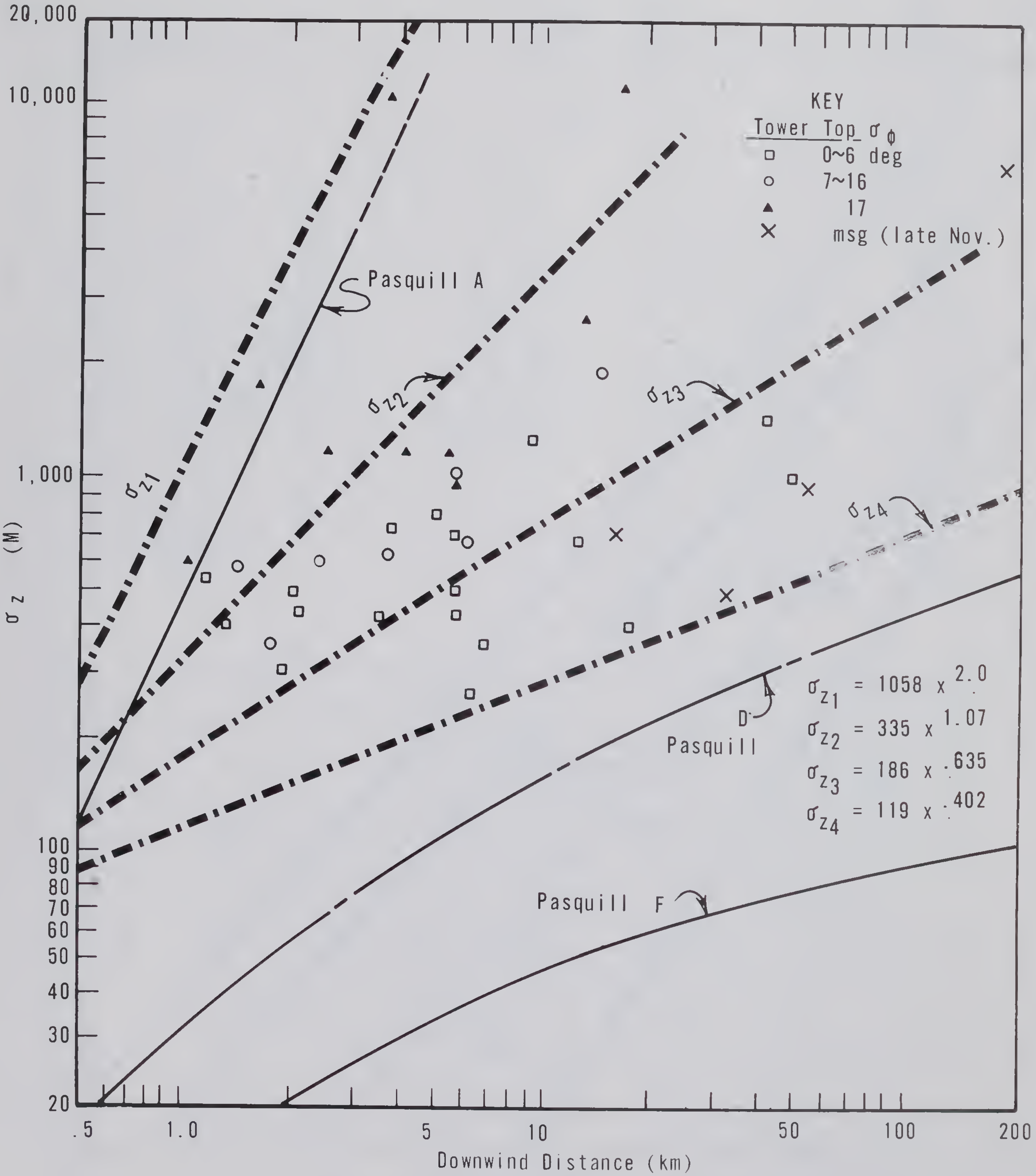
b. Short Term Model Accuracy

The lack of existing pollutant sources in the Colstrip area similar to the proposed units



Extreme Plume Widths (Left Ordinate) as a Function of Downwind Distance. The Right Ordinate gives a Scale for Converting these Widths to Horizontal Standard Deviations in Meters.

FIGURE 11-12



Vertical Standard Deviation versus Downwind Distance. The Points have been Stratified by Three Classes of Vertical Wind Direction Standard Deviation, σ_ϕ

FIGURE 11-13

(noted in the discussion of the long-term model accuracy) means that a verified quantitative assessment of the short-term model accuracy cannot be made. The limited amount of ground and low level ice nuclei concentration data measured during the plume tracing study mentioned in connection with the dilution model may be useful in obtaining some idea of the short-term model accuracy, but the necessary analysis has not yet been completed. How well the vertical and horizontal dispersion data are finally stratified versus meteorological parameters will also effect the possible error in the short term model predictions.

11.1.1.4. Summary of Air Quality Impact Evaluation

A. Ambient Air

As discussed in the "Long Term Model Results" Section 11.1.1.3., the diffusion model analysis using a Gaussian model has not indicated that annual ambient air concentrations of SO_2, NO_x, or particulates resulting from the operation of Colstrip Units 1-4 would exceed Montana or Federal annual standards.

At this time, the State does not possess sufficient information to make a decision with respect to the compliance of Colstrip Units 1-4 with existing Montana and federal short term ambient air standards. Work is continuing to develop the information necessary for a decision.

The compliance of Colstrip Units 1-4 with the Montana standards for sulfuric acid mist has not been addressed because the State is not aware of any reliable techniques applicable to a coal-fired power plant for estimating sulfuric acid mist concentrations.

B. Emissions

As discussed in Section 8.4.4. the proposed facility emission rates calculated from average coal content data and equipment design guarantee values would comply with Montana and federal emission rates. The control system design and the emission rates guaranteed by the vendors fall within the realm of available air pollution control technology. However, the federal sulfur dioxide emission standard may be exceeded for short periods (on the order of one hour) due to fluctuations of the coal sulfur content from the average value.

Emission standards for sulfur dioxide and particulate may also be exceeded if the proposed removal efficiencies for these two pollutants are not obtained in continuous plant operation. (Figures 8-16 and 8-17 in Section 8.4.4. give particulate and sulfur dioxide emission rates versus coal content and removal efficiencies.)

Should the proposed facility be approved, HES would further review the air pollution control systems under the state permit requirements (Section 69-3911, R.C.M. 1947).

C. Non-Degradation (Significant Deterioration)

In addition to state and federal emission and ambient standards, the U.S. Environmental Protection Agency (EPA) and the state of Montana eventually must develop "a mechanism for preventing significant deterioration of air quality in areas where air pollution levels currently are below the national ambient air quality standards" (38 Federal Register 1973, p. 18986). The Federal Register submitted for public comment various options for implementing the non-degradation concept. As a result of public comment the EPA soon will issue more definitive guidelines. A preview of these guidelines was put forth in a letter to Governor Judge from Russell Train, EPA Administrator, dated July 11, 1974. The letter said, "Following a public hearing each state would classify its presently clean areas into any of three categories:

1. a preservation area, in which very limited growth in emissions and deterioration of air quality would be allowed (Class I).

2. a moderate emissions growth area, in which modest increases in emissions and deterioration of air quality could occur (Class II).

3. an intensive emissions growth area, in which emissions could be allowed to deteriorate air quality up to the national standards (Class III)."

Mr. Train stresses the need to incorporate air quality considerations into overall land use planning, but says that action on significant deterioration should not be delayed in deference to pending passage of land use legislation.

In the absence of specific quidelines and regulations for the state to follow in implementing federal non-degradation requirements, the compliance or non-compliance of the proposed generating facility is uncertain.

Until non-degradation guidelines are issued by the federal government and implemented by the state, the status of the proposed generating plants' emissions in regard to the non-degradation concept is uncertain.

D. Certification

Pursuant to the Utility Siting Act "duly authorized state air and water quality agencies must certify that the proposed facility will not violate state and federally established standards and implementation plans..."

Preliminary analysis indicates there is insufficient information at this time for the Air Quality Bureau of HES to certify that the proposed facility would be capable of meeting both state and federal ambient and emsssion standards. Evaluation of data by MSU, HES and the Energy Planning Division is continuing. However, final certification by the Air Quality Bureau may be affected by federal government guidelines governing the non-degradation (significant deterioration) concept.

11.1.1.5. Fog Enhancement

An analysis of the potential fog enhancement attributable to the mechanical draft wet towers proposed for Colstrip is contained in MPC's Environmental Analysis (referred to as Westinghouse 1973).

This report examined the one year of temperature and surface humidity data available for Colstrip /15 and concluded "...the most frequent number of hours when the saturation deficit is low enough to cause fogging problems often occurs at or around 0°C. Since most of the potential ground fogging, then, will occur around 0°C, it will be accompanied by a thin layer of rime ice which will form on objects downwind of the cooling towers" (p. 2-117). (Appendix A14 is Westinghouse's table of temperature-humidity frequencies, which was generated from the year of available data).

Using the Gaussian diffusion equations to describe the diffusion of the water vapor emitted from the cooling towers and the aforementioned temperature and suface humidity data, Westinghouse made predictions of both the number of hours per year and the downwind extent of additional ground fog that would be due to cooling tower operation. The total number of additional hours per year for all directions around Colstrip was estimated to be 505 hours. The additional number of hours per year predicted for various locations included: 121 hours for sections of Highway 315 adjacent to Colstrip; 46 hours for mining areas located about 3000m southeast of the plant; 37 hours for "main plant buildings"; 24 hours for the town of Colstrip, located about 1200m west of the plant (or "...on the average, an hour of ground fog every four days during this (cold) season."); and between 18 and 37 hours for "...farms scattered around the plant" (p. 2-117).

Because the method of calculation, the accuracy of the predicted additional hours, and especially the values of the downwind extent of ground fog is questionable. Westinghouse based its decision of whether or not fog would be expected to occur on a comparison of the saturation water vapor concentration and the sum of the ambient concentration and the water vapor contribution due to the cooling tower. Both the ambient and saturation water vapor concentrations were calculated from the Colstrip surface temperature and surface humidity data. The cooling tower contribution at a given downwind distance was calculated using the Gaussian dispersion equations and the Pasquill Gifford dispersion coefficients. If the sum of the ambient and the cooling tower contributions exceeded the saturation concentration, fog was expected to occur; if the sum was less than saturation, fog was not predicted.

Two significant potential sources of error exist in this approach. First of all, according to Turner (1970) one of the basic assumptions of the Gaussian model is "The material diffused is a stable gas or aerosal...' (p. 17); Stern et al. (1973), stated the same assumption somewhat differently: "The notion underlying this approach (i.e., the Gaussian Plume Model) is that each particle of contaminant moves in random fashion through continuous time and space, independently of the presence of any other particle."(p. 277) Thus, the Gaussian model by itself cannot be expected to accurately describe the diffusion of water vapor when condensation is occurring. Secondly, as pointed out by Corrin et al. (1974, p. 114):

> A parcel of atmospheric air depends upon two basic factors for the initiation of fog:
>
> 1. Correct concentrations of nuclei upon which water vapor may condense, and

2. Water vapor concentrations which are large enough to initiate the condensation onto the nuclei.

In other words, the 100% relative humidity criteria (saturation) applied by Westinghouse is not a necessary and sufficient condition for fog initiation. Depending on the number concentration and chemical composition of the available condensation nuclei, fog may be initiated at relative humidities somewhat less than 100% and may not be stable at relative humidities greater than 100%.

For these two reasons the accuracy of Westinghouse's predictions of the total number of additional ground fog hours per year and the number of hours per year at different locations probably cannot be evaluated without actual field measurements.

Because verified models for predicting fog initiation apparently have not been reported in the literature, a quantitative assessment of known accuracy of the fogging potential of the proposed towers at Colstrip cannot be made.

Qualitatively, any fog enhancement by the cooling towers should be expected primarily during the colder months when the water vapor carrying capacity of the atmosphere is low, and only in the local vicinity (probably within a two to three mile radius) of the plant site. The U.S. Weather Service estimates that Colstrip currently has about ten days of heavy fog per year (Rammer 1974). This is somewhat of an indication that the potential for increased amounts of fog at Colstrip is not high. Cooling tower fog enhancement would therefore probably be only an intermittent problem. On those infrequent occasions when temperatures drop below about -30°C, ice fog may form as a result of cooling tower operation (Ohtake 1970).

A. Drift Deposition

Westinghouse applied the drift deposition model developed by Roffman et al. (1973) to the mechanical draft cooling towers for Colstrip. Data input to the model included the expected drift rate (.005% of the circulating water flow) and an assumed initial size distribution of the drift droplets.[16] The concentration of total dissolved solids in the cooling tower circulating water (also used as model input data) was the design maximum allowable circulating water concentration. The estimate by Westinghouse of the average chemical composition of the cooling tower blowdown (i.e., at the maximum allowable total dissolved solid concentration) is given in Table 11-7. The predicted deposition rates of total dissolved solids varied from about 57 to 83 kilograms per square kilometer per month, with maximum rates occurring at about 0.5 km from the center of the cooling towers. According to Westinghouse "...the environmental impact (of the preceeding values) is considered to be insignificant" (p. 2-118).

TABLE 11-7

Estimated Average Chemical Composition of Cooling Tower Blowdown

Constituent	Average Concentration, ppm
Ca	365
Mg	122
Na	357
SO_4	1839
Cl	59
HCO_3	1015
SiO_2	93

Source: Westinghouse (1973)

Because of the apparent lack of actual initial drift size distributions for mechanical draft cooling towers and the lack of any field verified drift deposition models, a quantitative assessment of the accuracy of the preceeding predictions cannot be made. Westinghouse did not report any estimates of the magnitude of the error inherent in their predicted rates. Lacking such information the validity of assessments of the environmental significance based on the preceeding 57 to 83 kg/km/month of total dissolved solid deposition is unknown.

11.1.1.6. Visibility Impacts

Westinghouse (1973) made calculations of the reduction in visual range resulting from the particulate emissions at Colstrip. The method of calculation used the empirical equation developed by Ettinger et al. (1972) which predicts visual range as a function of total mass concentration of suspended particulate for a low pollution nonurban environment. Using maximum predicted particulate concentrations /17 and representative background concentrations, Westinghouse obtained the following results:

> Reduction in 24 hr. visibility ranges from 15% under unstable atmospheric conditions (Pasquill Class A) to 3% under stable conditions (Pasquill Class F). Annually, reduction in visibility ranges from 0.7% to 0.4% (p. 2-118).

Westinghouse concluded, "This reduction in visibility is minimal even in nonurbanized areas, especially when it is considered that the calculations were made with respect to the maximum particulate concentrations" (p. 2-118).

As was discussed in Section 11.1.1.2., visibility reduction by particulates is usually assumed to be primarily due to scattering effects. Scattering by particulates is directly related to particle size distribution rather than mass concentrations. According to the Air Quality Criteria for Particulate Matter, (1969, p.55) "...a narrow range of particle sizes, usually from 0.lu to lu radius controls the extinction coefficient and therefore the visibility." Therefore, in order for the equation of Ettinger et al. to be applicable to Colstrip, the particulate size distribution, or at least the 0.1u to 1u portion of the distribution, resulting from the Colstrip operations would have to be equivalent to that existing in the low-pollution nonurban environment for which the equation was developed. Such an equivalence would appear very difficult to demonstrate for the following reasons: the particulate emissions from Colstrip will consist primarily of the small particles as the efficiency of the particulate removal equipment decreases with particle size (See Section 8.4.4.), the existence of a self-preserving particulate size distribution in the atmosphere is not proven (Ettinger et al. 1972, and Hidy 1972); the observed particulate size spectrum both near the ground and at higher altitudes "...may be largely source dominated" (Hidy 1972, p. 109); and even if the tendency to form an equilibrium distribution does exist, some finite time period would probably be required to reach the equilibrium state.

An increased reduction in visibility over that directly attributable to the particulate emissions alone may occur under conditions of high humidity because of the oxidation of SO_2. According to the Air Quality Criteria for Sulfur Dioxide (1970), the ratio of sulfuric acid to SO_2 increases with relative humidity. The formation of sulfuric acid droplets in the 0.1 to 1u size range may increase scattering and reduce visibility. The Air Quality document proposes a method for calculation of visible range as a function of total mass concentration of suspended particulates (all components of particulates except the sulfuric acid fraction are assumed to be nonhygroscopic), SO_2 concentration, and relative humidity. This method was applied for 90% relative humidity, average SO_2 and suspended particulate background values (0 and 10 ug/m^3, respectively), and assumed 24-hour SO_2 and particulate concentrations (260 ug/m^3 and 10 ug/m^3, respectively). Details of the calculation are given in Appendix A13. Results of the calculation indicated that the sulfuric acid droplets assumed to be produced by the sulfuric dioxide emissions and the 90% relative humidity reduced the background visibility range by about 80%.

No claim is made here that this method of visual range calculation is applicable without modifications to power plant emissions. The same problem exists with the use of total mass concentration of particulates as with the Ettinger et al. equation discussed above. Also, other empirical parameters used in the equation (such as the sulfuric acid concentration assumed to result from the SO_2 concentration and the 90% relative humidity) may not be applicable to power plant plumes. What the results may show is that if high relative humidity occurs with conditions corresponding to maximum SO_2 concentrations at Colstrip, the effect on visibility due to sulfuric acid mist production may not be negligible.

Because equations for visual range applicable to the emissions from power plants in a rural environment evidently have not been developed, no valid quantitative assessment of visibility reduction can be made. However, because the size distribution of the particulate emissions from the proposed units at Colstrip will be biased towards the small particles, and because of potential visibility reduction due to sulfuric acid production during periods of high humidity, the reduction of visibility may be greater than that predicted by Westinghouse.

11.1.1.7. Stack and Cooling Tower Plume Mixing

When sulfur dioxide (SO_2) exists in the presence of water in the atmosphere, sulfuric acid (H_2SO_4) can be produced (U.S. Dept. of HEW 1970, Gartrell et al. 1963). This reaction can proceed through catalytic oxidation of SO_2 to sulfur trioxide (SO_3), which then reacts with water to produce H_2SO_4. Also, H_2SO_4 can be produced by direct reaction of SO_2 and water also in the presence of a catalyst (U.S.Dept. of HEW 1970). Since several potential catalysts for these reactions may be present in coal-fired power plant plumes, predicting the rate of oxidation of SO_2 is probably impossible./18 However, the ratio of sulfuric acid to SO_2 is known to increase with humidity (U.S. Dept. of HEW 1970). The mixing of the moist cooling tower plume with the stack plume containing SO_2 may, therefore, increase sulfuric acid production. The degree of mixing will be a function primarily of wind direction and plume centerline height. Maximum mixing will occur when the stack and cooling tower are aligned directly downwind and when the plume centerline heights are equal.

Westinghouse (1973) calculated the "mean effective plume height" of the stack and cooling tower for each of six Pasquill stability classes (designated A through F). According to Westinghouse, the calculations "...indicate(d) that the centerlines of all plumes will never be at the same height." They state further, "Therefore, only partial interaction between the vapor plumes and stacks can occur" (p. 2-118).

Although not specifically stated in their discussion on potential plume rise, Westinghouse probably used the equations of Briggs (1969) to calculate the effective plume rise of the stack and cooling towers, as Briggs' method is cited elsewhere throughout their report. As pointed out by Hanna (1972), Briggs' equations apply to a dry, buoyancy-dominated plume.

In the case of moist plumes, the release of latent heat due to condensation may increase the buoyancy of the plume and thereby enhance its final rise. Hanna (1972) suggested a simple method of accounting for latent heat release through modification of Briggs' equation for the initial plume buoyancy flux. According to Hanna (p. 794), for initially saturated moist plumes, "the total possible initial buoyancy flux...is... given by:

$$F_o = gW_oR_o^2\left[\frac{Tvpo-Tveo}{Tvpo} + (qpo-qeo)\frac{L}{Cpt}\right]$$

where F_o=initial buoyancy flux
g=acceleration due to gravity
W_o=initial plume vertical speed
R_o=initial plume radius
Tvpo=initial plume virtual temperature
Tveo=initial environmental virtual temperature

qpo=initial plume saturation specific humidity

qeo=initial environmental specific humidity
L=latent heat required to evaporate one gram of water

cp=specific heat of air at constant pressure

Hanna compared the results obtained using this simple approach with the plume rise predicted using a numerical cloud growth model. For environmental relative humidities of 100%, the cloud growth model predictions were within 40% of the results obtained using the equation above.

Hanna's equation for moist plume rise together with Briggs' dry plume rise equations were applied to the proposed Unit 3 and 4 cooling towers and stacks to calculate effective plume heights. For purposes of comparison, the cooling tower effective height was determined using both approaches, the "wet" approach using the above equation which is applicable for high environmental humidities, and the "dry" approach using Briggs' equations for the low humidity conditions. For the "wet" cases an environmental relative humidity of 100% was assumed.

Details of the calculations are given in Appendix A12. Table 11-8 contains the assumed meteorological conditions and the resultant stack and cooling tower plume centerline heights. Table 11-9 contains the stack and cooling tower parameters used in the calculation.

As Table 11-9 indicates, the cooling tower effective plume centerline height does not equal the stack centerline height for any of the meteorlogical conditions examined. The ratio of the cooling tower plume height to the stack plume height for the "wet" case is about 0.7 for stable conditions and 0.4 to 0.5 for neutral and unstable conditions. For the "dry" case the ratio varies from about 0.4 to 0.5 for stable conditions and about 0.2 for neutral and unstable. Because Hanna's equation attempts to predict the maximum total initial buoyancy flux due to the initial temperature excess and latent heat release, and neglects any drag effects due to condensed water, the predicted plume heights for the "wet" case should probably be maximum or "worst case" values. Also, the initial temperature of the cooling tower plume was set equal to the design hot water temperature (about 318°K), which is probably higher than the actual temperature would be./19 This assumption will also tend to maximize the final plume height. Thus Table 11-8 data appears to substantiate the conclusion reached by Westinghouse for the atmospheric condition of unlimited mixing.

For conditions of limited mixing caused by an inversion "capping" a neutral or unstable layer the problem is somewhat more complex. Because of their different initial buoyancies, cooling tower and stack plumes will have different potentials for penetrating inversions or stable layers. However, the possibility of inversions or stable layers significantly enhancing plume mixing cannot be eliminated on the basis of existing theory and field studies. Stockham (1970) reported visual co-mingling of the stack and natural draft cooling tower plumes at Keystone (Pennsylvania) on the morning of December 6, 1969./20 Vertical cross sections generated from aircraft flights through the plume confirmed the mixing. The maximum SO_2 concentrations and relative humidities overlap on the cross sections about 50 to 100m beneath a temperature inversion. Stockham did not attempt to analyze the effect of the inversion on the stack and cooling tower plume rise.

One additional point should be made with respect to the approach used to calculate the cooling tower plume rise. Meyer et al. (1974) in

TABLE 11-8: Stack and Cooling Tower Effective Plume Height

Stability Category	U m/sec	Ta (^{0}K)	$\frac{\Delta\Theta}{\Delta Z}$ (^{0}C/m)	Stack He (m)	Cooling Tower	
					Dry He (m)	Wet He (m)
Stable	2	263	.04	362	163	254
	2	273	.04	357	156	251
	2	268	.03	379	174	276
	2	273	.03	376	169	275
	2	273	.02	407	191	312
	4	268	.04	318	131	205
	4	273	.03	332	138	222
	4	278	.02	353	151	250
Neutral	6	273	-	511	104	240
	6	278	-	504	98	234
	6	283	-	496	92	228
	6	288	-	488	86	216
	10	273	-	381	70	152
	10	278	-	366	67	149

TABLE 11-8 (cont.): Stack and Cooling Tower Effective Plume Height

Stability Category	U m/sec	Ta (°K)	$\frac{\Delta\Theta}{\Delta Z}$ (°C/m)	Stack He (m)	Cooling Tower Dry He (m)	Cooling Tower Wet He (m)
Neutral (cont.)	10	283	-	362	63	144
	10	288	-	357	59	139
Unstable	2	288	-	1143	219	621
	3	288	-	815	152	420
	3	298	-	779	124	372
	4	293	-	638	109	304

TABLE 11-9: Stack and Cooling Tower Parameters

	Physical Height (m)	Effluent Exit Velocity (m/sec)	Radius (m)	Initial Exit Temperature °K
Stack	160	30.34	3.66	352
Cooling Tower	19.1	9.6	4.75	318

their field and modeling study of a mechanical draft cooling tower noted that "The case of a (mechancial draft tower) multi-port plume with large volume flux and large initial vertical momentum, which slowly combines into one as it bends over, severely strains the assumptions of the standard, bent-over plume rise formulations" (p. 52). Thus, a question exists concerning the validity of the application of Briggs' and Hanna's equations to typical mechanical draft towers.

To summarize, existing modeling techniques indicate that the final effective plume height of the stacks and cooling towers proposed for Units 3 and 4 probably will not be equal under conditions of unlimited mixing. However, the accuracy of the plume rise modeling technique used for mechanical draft towers is not known. Although the effect on plume mixing of inversions or elevated stable layers on plume mixing is not well understood, results of one field study suggest that these atmospheric conditions may on occasion produce plume co-mingling and thereby maximize sulfuric acid mist production. Even if the degree of plume mixing could be adequately predicted under all atmospheric conditions, valid estimates of the amount of sulfuric acid produced could not now be made because the complex chemistry of fossil fuel power plant plumes is also not well understood.

11.1.2. Hydrological and Water Quality Impacts

This section includes assessments of impacts of Units 3 and 4 on water quantity and quality for both surface and ground water. Impact assessments of acid rain damage to vegetation are presented in Section 11.1.5.2.

11.1.2.1. Surface Water

A. Water Quantity

The percent decrease in the stream flow at two USGS stream gaging stations on the Yellowstone River as a result of the 59 cfs withdrawal is shown in the following table. Low flows in Table 11-10 are historic low flows and may not be repeated, especially considering the regulatory capacity of Yellowtail Dam.

Table 11-10

USGS STA 06309000 Yellowstone River at Miles City, Montana. Base period 1929 - 1971.

	Percent Decrease Due to 59 cfs Withdrawal
1 day mean low flow = 996 cfs	5.9
3 days mean low flow = 1032 cfs	5.7
7 days mean low flow = 1222 cfs	4.8
Mean annual flow = 11,330 cfs	0.5
Highest recorded flow = 96,300 cfs	0.06

USGS STA 06329500 Yellowstone River at Sidney, Montana. Base period 1911 - 1971.

	Percent Decrease Due to 59 cfs Withdrawal
1 day mean low flow = 470 cfs	12.6
3 days mean low flow = 783 cfs	7.5
7 days mean low flow = 1013 cfs	5.8
Mean annual flow = 13,030 cfs	0.5
Highest recorded flow = 159,000 cfs	0.04

The current stage discharge curve for the USGS gaging station on the Yellowstone River at Miles City may be used to determine the effect a 59 cfs withdrawal will have on the stage of the Yellowstone River in that vicinity. For streamflows greater than or equal to 2,250 cfs a withdrawal of 59 cfs would result in a stage reduction in water surface elevation of 0.05 foot (0.6 inch), or less as the streamflow increases. For streamflows less than 2,250 cfs, the withdrawal would result in a reduction of 0.05 foot (0.6 inch), or greater as the streamflow decreases.

Also the current stage discharge curve for the USGS gaging station on the Yellowstone River near Sidney may be used to determine the effect a 59 cfs withdrawal will have on the stage of the Yellowstone River in that vicinity. For streamflows greater than or equal to 5,200 cfs, a withdrawal of 59 cfs would result in a stage loss of 0.02 foot (0.25 inch), or less as the streamflows increase. For streamflows less than 5,200 cfs, the withdrawal would result in a stage reduction of 0.02 foot (0.25 inch), or greater as the streamflow decreases.

B. Water Quality

The proposed power plants and the two power plants under construction will cause a variety of impacts on the area's water resources. These impacts, summarized in matrix format in Section 11.1.2.5., affect various water quality parameters and range in severity from no impact to severe impact.

1. Local Impacts

a. Leaching of Solid Wastes

i. Coal Piles

Coal will be stockpiled at various locations awaiting feeding to the power plants. Storage piles will be compacted and will be surrounded by drainage ditches; Westinghouse (1973) states that water runoff from coal is not acid. Ponds of water in the Colstrip area are in contact with in-place coal or coal-bearing wastes and production of acid water has not been a problem. In view of the semi-arid climate and limited extent of coal piles, it is doubtful that these would have any impact on the area's water resources.

It is proposed (Westinghouse 1973) that coal pile drainage will be impounded to settle out dust, then discharged to the stream. Discharges to streams must be in compliance with Montana's water quality standards and would require a state permit. Adherence to these standards would prevent degradation of stream water quality.

Seepage beneath coal piles could have an impact on groundwater quality. Leachate from coal piles, however, will be limited in quantity and probably will not have a significant water quality impact. If future testing of coal pile leachates indicates seepage of poor quality water, then impervious storage pads may become necessary.

ii. Spoil Banks

According to Westinghouse (1973), reclamation of strip-mined areas at the Western Energy Company mine near Colstrip will be conducted concurrently with mining, at a distance of two spoil ridges behind the active mining area. In addition, diversion ditches will be used to divert runoff around the spoils. Runoff from the spoils will go through settling ponds and, if necessary, be treated to avoid surface water pollution (Department of State Lands 1974).

Since only a few tens of acres of spoils will be exposed and inflow and outflow are controlled, there should be little impact to surface waters from spoils runoff.

b. Potential Discharge from Water Storage Systems

i. Ash Pond

The ash pond made necessary by the coal conversion process of Units 3 and 4 would be located in a small valley east of the proposed plant site. The pond would be sealed, and would be designed to accommodate any runoff without overflowing (Westinghouse 1973). Since no out-flows are anticipated, this facility should have no impact on surface water quality.

ii. Surge Pond

The surge pond well would be about 150 acres in area and would be developed for recreation (Westinghouse 1973). Since there is not expected to be any direct overflow from this pond to surface waters, no surface water quality impact should occur.

iii. Sewage Lagoons at Colstrip

The sewage disposal system for the community of Colstrip consists of gravity mains, two package lift stations, and a three-cell lagoon with a total surface area of approximately 10.3 acres. The population served by this system is about 2,000. Presently, there is no water in the third cell; thus, the system is not discharging. The volume of sanitary wastes has increased rapidly and additional waste treatment facilities will be needed in the near future. It is expected that there will be no discharge of sanitary wastes into surface waters in the area. Any discharges to surface waters will be regulated by the Montana Pollution Discharge Elimination System and Montana Water Quality Standards; thus no adverse impact on surface waters is expected.

c. Cooling Tower Drift

One cooling tower will be used for each generating unit at Colstrip. Water will be pumped from the Yellowstone for the cooling towers, which will interact with hydrologic systems via drift. The drift will deposit an estimated 4.05 kg/sec. (approximately 760 pounds per day) of solids (Westinghouse 1973). Deposition rates on the ground are estimated to be 0.5 to 0.7 lb/acre per month. These figures indicate that cooling tower drift would be a minor source of solids and should have little or no impact on water quality. However, the accuracy of these figures is not known, since the model used to generate them has not been checked against actual drift of any operating towers.

The interaction of cooling tower drift and stack sulphur emissions is discussed in Westinghouse (1973) as a mechanism for generation of acid drift. Production and dispersion of acid mist is expected to occur in small quantities, and would not be expected to have an impact on water quality; however, the reliability of this prediction is untested.

2. Regional Impacts

a. Stack Emissions

Particulates and gases emitted from stacks have been reported to create numerous water quality-related problems. Acid rains have been directly linked to sulphur emissions. Stack emissions for the proposed Units 3 and 4 and Units 1 and 2 will influence hydrologic systems and will have an impact on water quality.

The quantity and the chemical and physical characteristics of constituents which would be emitted from the stacks of Units 3 and 4 has not been definitely established, particularly the emission rate of toxic metals. The hydrolysis of certain components of stack gases in the atmosphere and prediction of distribution of particulates in the ground is difficult to quantify.

Similarly, the dissolution of fallout and rainout from stack gases is poorly understood. The mechanism and rate of transport to water bodies and rate of mixing with water systems has not been investigated.

To appraise the effects of the 263 tons per day of sulfur dioxide planned emission from the four power generation plants, a comparison with similar plants can be made. The plants in East Helena emit an estimated 312 tons per day of sulfur dioxide, and the Anaconda Company in Anaconda emits about 1,030 tons per day of sulfur dioxide. Water quality investigations in the vicinity of these plants have not shown significant pH depressions in nearby streams. The alkalinity of waters in the Colstrip area is significantly higher than in waters near Helena and Anaconda. This comparison suggests that acid production from sulfur oxide emitted from Colstrip Units 1, 2, 3, and 4 will not create significant pH changes in nearby streams.

Emission rates for three elements were given in Westinghouse (1973). These are fluoride (6.8 pounds per hour), lead oxide (0.97 pounds per hour), and mercury (0.35 pounds per hour). To estimate the potential impact of these elements on water systems, it was assumed that the elements were directly placed in streams. The rate of addition was assumed equal to the stack emission rate and instantaneous and complete dissolution was assumed. Results of these calculations (Table 11-11) indicate very low concentrations, even when assumed dispersed in Rosebud Creek. Concentrations calculated from this extreme are still very low. There appears to be no reason to assume adverse concentrations of these elements will occur in streams in the area.

A number of other potentially toxic constituents are known to be present in stack emissions, as discussed in Section 8.4.4.3. The relationship between these emission rates and the impact of these constituents on water resources is undetermined.

Table 11-11

HYPOTHETICAL CONCENTRATIONS (in mg/l) OF FLUORIDE, LEAD OXIDE, AND MERCURY FROM COLSTRIP STACK EMISSIONS (ALL STACKS) ASSUMING CONTINUOUS, INSTANTANEOUS AND COMPLETE DISSOLUTION OF ALL LISTED POLLUTANTS.

STREAM	HG	F (all forms)	PbO
Tongue River (423 cfs)	0.00031	0.022	0.00043
Yellowstone River (13,030 cfs)	0.000010	0.00072	0.00001
Rosebud Creek (24 cfs)	0.0054	0.39	0.0075

b. Impacts From Point and Non-Point Sources Due To Population Increases

Generation development at Colstrip will result in large population increases in southeastern Montana and will generate additional sewage treatment needs. State and federal regulations require municipalities to meet secondary treatment requirements by July 1, 1977. Due to population increases, facility investments in this area will be greatly increased. This in turn will necessitate additional federal and/or state funding to improve treatment works.

In addition to municipal wastewater treatment problems, a variety of non-point pollution could arise from various types of ground disturbances such as housing, road, and plant construction. Increased populations will result in an increase of pollutants entering streams via urban runoff and storm sewers. The number of housing developments will increase, some of which will not be connected to central sewer systems. This will result in increased use of septic tanks or seepage pits, which will degrade groundwaters. With an increased number of people and vehicles, an increase in the number of "accidents" or inadvertent spills of toxic or deleterious materials into streams or underground water systems will occur.

3. Yellowstone Dewatering Effects on Water Quality

It is proposed to divert 46 to 59 cfs from the Yellowstone River to supply water (primarily cooling) to the four planned generation units. This flow diversion will have maximum impact on water quality during the lowest river flows (fall, winter, and early spring). As described in the hydrology section (10.1.3.), the Yellowstone River below its confluence with the Bighorn River is partially regulated. Since 1967, low flows in particular have been influenced by releases from Yellowtail Dam.

To approach the problem of increased concentrations of pollutants in the Yellowstone River at low flows, the USGS surface water and water quality records were examined for the years 1967 to 1972 for the Yellowstone and Tongue Rivers at Miles City. These records indicate that the lowest daily flow for this period for the Yellowstone River above the confluence of the Tongue River was 2,450 cfs. The quality of waters in the river was estimated by averaging water quality data obtained during low flows. These average concentrations and a flow of 2,450 cfs were used to estimate low-flow daily loads in the Yellowstone River at Nichols (the point of diversion for Colstrip). The estimated daily loads calculated for selected constituents are:

TDS (Total dissolved solids)......	6,650 tons/day
TSS (Total suspended solids)......	3,000 tons/day
BOD_5	20 tons/day

Water removal from the Yellowstone reduces the waste-diluting capability of the river. There are a number of municipal sewage treatment facilities that discharge to the Yellowstone downstream from Nichols. The impact of the proposed water diversion is to slightly increase concentrations of constituents in the river as shown in Table 11-12.

Two industries--Montana-Dakota Utilities and Holly Sugar Company --are discharging into the Yellowstone downstream from Nichols. The Montana-Dakota Utilities discharge presently increases total dissolved solids in the Yellowstone River by 0.035%. After diversion of water for Colstrip, the calculated increase is 0.036%. Similarly, Holly Sugar Company when discharging increases BOD in the Yellowstone River 15.7%. After diversion for Colstrip, the calculated increase is 15.8%.

TABLE 11-12

CALCULATED PRESENT LEVELS AND PERCENT INCREASE OF CONSTITUENTS IN YELLOWSTONE RIVER*

Community	BOD5 Present	BOD5 After Diversion	TSS Present	TSS After Diversion
Forsyth	0.02	0.02	<0.001	<0.001
Miles City	0.23	0.24	0.001	0.001
Terry	0.04	0.04	<0.001	<0.001
West Glendive	0.03	0.04	<0.001	<0.001
Glendive	0.32	0.32	0.002	0.002

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*Based on community average daily discharge when discharging. Also, it assumes a 50 cfs diversion to Colstrip (typical diversion during low river flows).

Downstream from the Colstrip diversion, there are three significant streams that flow into the Yellowstone River. These are Rosebud Creek and the Tongue and Powder Rivers. These streams have poorer quality water than does the Yellowstone; thus, they degrade the quality of the Yellowstone River. The impact of the proposed diversion on Yellowstone River water quality is shown in Table 11-13.

Table 11-13

CALCULATED PRESENT LEVELS AND PERCENT INCREASE OF CONSTITUENTS IN YELLOWSTONE RIVER DUE TO INFLOW OF TRIBUTARY

Stream	TDS Present	TDS After Diversion	TSS Present	TSS After Diversion
Rosebud Creek	1.2	1.2	0.2	0.2
Tongue River	3.9	4.0	0.3	0.3
Powder River	3.8	3.8	1	1

In addition to waters entering the Yellowstone from municipal and industrial sources and from other streams, the Yellowstone is influenced by irrigation return waters that enter the stream both in surface water conveyance systems and in groundwater flow. The decrease in diluting capacity of the Yellowstone will again cause these return flows to have a slightly greater impact on dissolved and suspended solids.

In summary, diversion of water from the Yellowstone River at Colstrip will cause a degradation of water quality downstream from the diversion, due to the decreased diluting capacity of the river. The decline in water quality, however, is expected to be slight.

11.1.2.2. Ground Water

A. Leaching from Waste Disposal Systems

1. Ash Pond

The proposed ash pond would be sealed (Westinghouse 1973), and if this sealing is effective, there should be no ground water impact from this facility.

2. Surge Pond

The surge pond site has low seepage characteristics (Westinghouse 1973); thus inflow to ground water systems should be minor. The quantitative impact of this seepage depends on the seepage rate, quality of the seeped water, and changes in quality while moving in the ground. Since details on these variables are not available, the impact on ground water cannot be determined. General characteristics of the area, surge pond water, and the geology suggest that the surge pond would cause no significant adverse impacts to ground water systems.

B. Alteration of Aquifers Due to Mining Activities

The impact of mining on aquifers is described in detail by Van Voast (1974). He states that the most obvious effect of mining will be the physical loss of wells and springs in the mined area. He further states,

> Depending on the sizes of actual mine areas, as many as 19 wells and 3 springs can be physically destroyed during the mining operations. In addition, 4 wells will probably experience severe water-level declines and may become unusable. Five wells and 2 springs will probably experience moderate water-level and yield declines, possibly decreasing their seasonal usability. Three wells and 1 spring will experience slight water-level and yield declines.
>
> Mine area C, due to the greatest density of wells in its vicinity and because of its upgradient position, will affect the most wells (19) and springs (3). Mine area B will affect 6 wells and 2 springs; area A will affect 4 wells; area D will affect 2 wells; area E will affect 1 well.
>
> Hydrologic conditions in affected areas will adjust after mining is completed until a post-mining dynamic equilibrium is reached.

C. Leaching from Spoil Banks

After mining, the spoils may be leached by waters percolating downward. These waters may originate as precipitation on the spoils or as infiltrated irrigation water. Minerals leaching from the spoils may result in moderate to high concentrations of minerals in ground water (Van Voast 1974). The impact of this leaching depends on the volume of water infiltrating the spoils, dissolution processes in the spoils, and the quantity and quality of natural ground water entering the spoils. None of these factors have been thoroughly examined and the cost of obtaining data needed to predict the water quality impact is enormous. Van Voast (1974, p. 10) concludes "It is not possible to predict what, if any, effects mining may have on water quality of these wells and springs."

To assess the potential impact magnitude, several factors should be considered.

1) Changes in ground water quality will be limited to aquifers down-gradient from the active mining and will be limited in vertical extent due to low vertical permeabilities in this area (Van Voast 1974).

2) Aquifers down-gradient from the mined area are not extensively used and alternative sources of ground water are probably available from other aquifers below the disturbed stratigraphic interval (Van Voast 1974).

3) Chemical quality of water in disturbed aquifers may not necessarily be of better quality than ground water in the spoil banks. Reliable quantitative predictions of water quality changes in aquifers as a result of mining are not possible.

4) Once water in an extensive aquifer is contaminated or degraded in quality, economic remedial measures are virtually non-existent.

5) Groundwater in selected aquifers down-gradient from the mine may be degraded over significant areas thus preempting their use for some purposes.

The summary of this discussion is that groundwater quality impacts due to spoil bank leaching cannot be quantitatively predicted. It appears that one result of mining may be a degradation of water quality in selected aquifers down-gradient from the mined area.

11.1.2.3. Impact Matrix

An impact matrix for surface water (Table 11-14) and ground water (Table 11-15) summarizes impacts of actions associated with coal development on water quality. Blanks on the matrices indicate that there is expected to be no interaction between the water quality component and construction or operational element involved.

11.1.3. Geologic Impacts

The interaction between the physical earth and man's activities is dominated by earth processes. There is greater potential for severe geologic impacts upon the plant than power plant impacts upon the earth. Earthquakes, floods, volcanic eruption, landslides, and other geologic phenomena are known for their destructive force. Man's activities are more often conducted in the faith that no catastrophic event will occur than scientifically assessing the dangers and acting accordingly. The building of cities on flood plains and in earthquake-prone areas are examples of this faith. If earth processes can destroy the works of man, man can have little impact upon the earth's geology. The geologic processes which man can and does alter, both intentionally and inadvertently, often result in further modifying man's activities. The initiation of a series of earthquakes in the Denver area by a waste disposal well had little effect on the earth, but the earthquakes damaged buildings and merchandise (Coffman and vonHake 1973). Similarly, polluted groundwater affects man's use of the water and the biological communities of the streams.

11.1.3.1. Geologic Impacts Upon the Power Plant

Structural failures may result from a number of causes. Foundation failure, the cause of the leaning of the Tower of Pisa, is a common hazard; however, proper engineering can overcome many similar hazards.

In Montana, earthquakes constitute a genuine danger; though proper engineering can design a power plant that will withstand some earthquakes, damage could result if a large tremor occurred nearby. The seismic activity and risk map (Section 10.1.4.6., Table 10-22) shows Colstrip to be in a low-risk area. Based upon the historical record of earthquake activity in Montana and the geologic setting of eastern Montana, there

TABLE 11-14: SURFACE WATER QUALITY IMPACT MATRIX

ACTIONS

Water Quality Components	Municipal Wastes and Urban Runoff	Stack Emissions	Spoilbank Runoff	Pumpage from Yellowstone River	Soil Disturbances	Pond Discharges
Major Ions[1]	V	0	V	0	0	V
Secondary Ions[1]	V	0	V	0	0	V
Suspended Sediment	V	0	V	0	S	
Toxic Metals[1]	0	0	0	0	0	V
Streamflows	V		0	0	0	V
pH	0	0	0			V
Nutrients[1]	V		0	0	0	V
Oxygen Parameters[1]	V				0	
Coliforms[1]	V				V	

V: Variable
0: Slight
S: Severe
1: See Table 10-19

TABLE 11-15: GROUND WATER QUALITY IMPACT MATRIX

ACTION

Water Quality Components	Aquifer Disruption by Mining	Spoil Bank Leaching	Seepage from Ash Pond	Seepage from Surge Pond	Municipal & Private Sanitary Wastes
Major Ions[1]		V	V	0	V
Secondary Ions[1]		V	V	0	V
Toxic Metals[1]		0	V		
Ground Water Flow	V		0	0	V
Nutrients		0			V

V: Variable
0: Slight
1: See Table 10-19

appears to be little likelihood of a destructive quake occurring near Colstrip. The absence of steep slopes, thixotropic sediments, large bodies of water, and the like eliminate secondary effects of earthquakes (see Section 10.1.4.6., Table 10-30). A well-engineered power plant at Colstrip is not likely to suffer earthquake damage during its projected life.

11.1.3.2. Geologic Environmental Impacts

Building and operating the proposed power plant, and related mining activity, will create certain environmental impacts which are geologic in nature. These impacts are:

1) Possible contamination of surface water and groundwater.

2) Alteration of aquifers due to mining activities.

3) Mining of non-renewable resources.

4) Destruction of geologic information and natural landscape.

The first two impacts are dealt with in Sections 11.1.2.2. and 11.1.3.3.

Non-Renewable Resources

Building the proposed Colstrip power plant would directly and indirectly consume vast amounts of non-renewable resources. Coal, iron, copper, aluminium, oil, natural gas, clay, limestone, sand and gravel, and many more earth resources would go into the plant. Coal, for instance, would be used to fire the boilers when the plant becomes operational, and coal would also be used to make the steel that goes into the plant. Clay, limestone, and other materials are fired by coal, oil, or natural gas to make cement, which is mixed with sand and gravel to form concrete. Copper wire is the electrical conductor inside the generators and transformers, and other metals go into the stainless steel used in the boiler tubes. Scores of square miles of mines throughout the world would contribute resources to build the proposed plants. Each year, 130 acres of southeastern Montana would be strip mined to supply the fuel.

In addition to the environmental impacts created by mining, the use of these resources deprives future generations of the use of them. Since in most cases current mining is taking the best, most easily attainable resources, future mining will depend on more advanced technology in mineral recovery and/or obtain less with greater effort.

Although the land surface may be regraded, the land morphology will be artificial. From an economic or biological point of view, the artificial morphology may not be of consequence. To the farmer growing crops on the land, a coyote hunting mice, or a casual passer-by, the new landscape may be fully adequate; however, to those persons capable of perceiving the absence of the natural condition through special interests or education, an aesthetic impact exists.

With the natural landscape gone, informational resources are also lost. All archeologic material, surficial geologic materials, and stratigraphic details of the overburden are irretrievably lost during strip mining. Within small areas, this loss is generally minute, but when thousands of acres are disturbed, the informational resources which are lost and the aesthetic and biological impacts add greatly to the environmental costs of the plant.

11.1.4. Impact on Soil

The possible impacts of Colstrip Units 3 and 4 on the soils in the study area are of three general categories: impacts on the soils due to the actual construction and maintenance of the power plants, possible impacts on the soil due to emissions of pollutants after the plants are in operation and the impacts due to mining of coal for the plants. Other land uses directly related to soil capabilities, especially agricultural, would be precluded by the physical presence of the power plants, but this impact is not considered significant because of the small amount of land involved.

The major impact upon the soils may be the chemical emissions from the power plant units. However, this impact is very difficult to analyze at this time because of limited research on this subject. With the chemical baseline data which has been established for the Colstrip area, such studies will be possible when Units 1 and 2 come on-line.

The pollutants which will be emitted from the plant (sulfur dioxide, nitrogen oxides, particulates, gaseous fluoride, solid fluoride, lead as monoxide, mercury, etc.) will also appear in the ash ponds. Alteration of soil chemical composition levels is possible if seepage of the ponds occurs. Because it is not known what the rate of oxidation of the chemicals is, it is also impossible to predict the potential extent of alteration of the soil. However, if the applicant uses sound construction techniques, seepage should not take place at the ponds.

The impact upon the soils due to the construction of the power plant and also the construction and maintenance of the water supply pipeline should be evaluated according to the overall Armells Creek watershed characteristics.

The sedimentation of Armells Creek will be affected very slightly due to construction and building sites creating more bare ground. However, the overall watershed must be considered with its steep escarpments and areas of bare ground; the large area of soil banks from the coal mines; the town of Colstrip; bare stream bottoms; highway and railroad right-of-way; and a few acres of dry land grain and bare summer fallow all adding their share of sediment when it rains. The sediment coming from the plant site and pipeline areas during construction would not be high enough to be considered a prime cause of pollution of Armells Creek. However, it should be stressed that any bare ground, loosely packed pipeline trenches, etc. must be planted with a cover crop as soon as possible after construction. Top soiling will be necessary because the high line C horizon will generally end up on the surface, and grasses and some legumes do not germinate properly on high line soils.

The actual area of construction of the power plant will remove land from production of native range grasses. Also the soil will be altered as to pH, texture, structure, and other related characteristics. However, the actual acreage disturbed is not large when considered in terms of the entire study area.

The compaction due to construction will also retard intake of moisture and rooting of plants. Thus, ripping of compacted areas and correct preparation of seed bed is necessary for proper reclamation.

In terms of the comparatively minor magnitude of soil disturbance discussed above, the following factors were considered in assessing the impact on soil due to construction:

1. Compacted soil erosion hazard, as indicated by the percentage of coarse fragments in the exposed horizons.
2. Limitations on revegetation potential climatic, fertility, saline/sodic soils, poor tilth, etc.
3. Drainage density pattern of the landform as it affects the probability of eroded material moving into the surface drainage system.
4. Average slope gradient as it determines necessity of cut-and-fill construction and limits soil development.

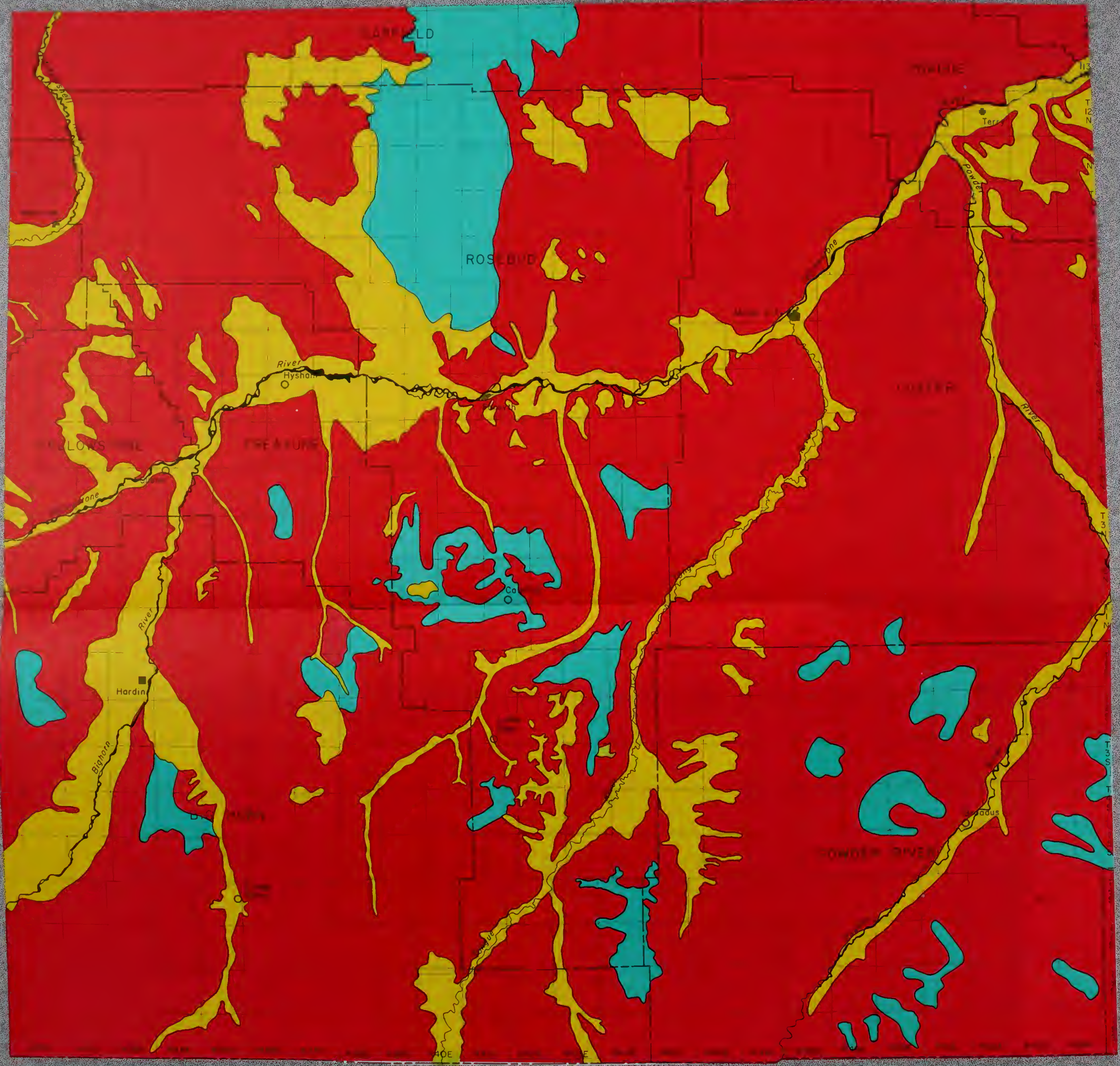
Refer to Appendix C1 for lists of impact parameters and interpretations.

The soils inventory resulted in forty distinct units in the study area. Each of the four parameters listed above was evaluated for each of the forty map units, and each map unit was accordingly given a sediment risk rating of severe, moderate, or slight. The resulting Sediment Risk Map included in this section shows groupings of areas of similar hazard ratings, although the critical factors causing the harzard rating may not have been the same even in adjacent units. This map was further refined by the incorporation of field data, especially where field observation identified a local inclusion that warranted a more severe rating than the larger unit in which it appeared.

11.1.4.1. Sediment Risk Ratings Defined

A. Slight

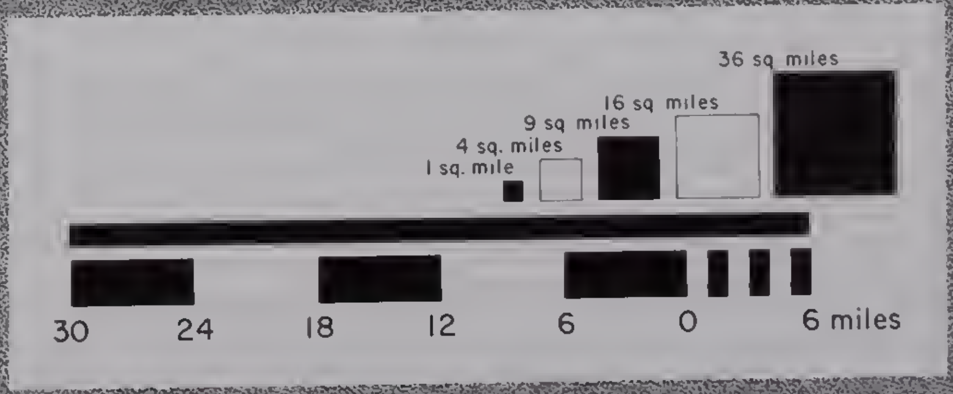
Areas rated as slight in sediment risk range from areas free of potential erosion hazards to areas which include hazards easily overcome at little or no extra cost. An example is the mountain soils (#1; see Section 10.1.5.) in the study area developing on consolidated bedrock. There is sufficient coarse fragment material in the soil to give the soil such cohesion and bearing strength that compaction does not present an erosion hazard. Factors such as relatively



SEDIMENT RISK

🟥 Severe
🟦 Moderate
🟨 Slight

SOURCE: USFS



fertile soil, sufficient moisture, and other climatic factors, present no limitations to reseeding of vegetation. Surface drainage (low order stream density) is not a factor in these soils, since most drainage is subsurface. The result, in spite of high relief, is only a slight sediment risk.

B. Moderate

A moderate rating is given to areas where potentially significant erosion hazards occur that can be overcome with proper design and construction methods. Construction cost would increase, but not to an extreme degree. An example of a unit with a moderate rating is the rolling shale uplands in eastern Montana which occur in the 14-20" precipitation zone. These are generally shallow soils underlain by soft shales; they have almost no gravel or cobbles in the profile, and their clayey texture presents a severe erosion hazard when compacted. This clayey texture results in poor tilth and limits reseeding of an erosion-control plant cover, but because these soils appear in a higher precipitation zone (14-20", using criteria developed by the SCS for range management evaluation) the overall limitation on revegetation potential is only moderate. Low order stream density is also rated as moderate and thus the overall rating for sediment risk in this unit is moderate.

C. Severe

Units with severe ratings are those with a high probability of sediment pollution of surface water resulting from disturbance of the soil mantle. Many of these hazards can be minimized by very careful design, location, and construction techniques, but with high costs. In some units the only way to avoid sediment risk is to avoid the unit. An example of a unit with a severe rating is the rolling shale uplands of eastern Montana, in the lower precipitation zone of 10-14" (SCS criteria). The compacted soil erosion hazard is severe and there are no coarse fragments in the profile to resist detachment and movement. The soils are shallow, sometimes with outcroppings of the soft shale bedrock. The clayey texture of the soils developing from this soft shale parent material results in poor tilth and limits the potential for revegetation. In addition, the rainfall often comes in short time periods, so the effective rainfall for vegetation is even lower than the actual average, which dictates a severe rating for erosion control plantings. This well-dissected unit has a relatively dense surface drainage pattern, with the soil remaining bare for long periods of time. The soil is susceptible to erosion and there is high probability that sediment will move into the surface drainage channels. The overall rating of the unit is severe.

11.1.5. Impacts on Vegetation

11.1.5.1. General Discussion

The following list enumerates the basic premises which form the foundation for predictions and conclusions concerning the effects of Units 3 and 4.

1) According to all data thus far gathered and reported, the flora and fauna of both indigenous and domestic species growing in the Colstrip area have seldom to never before been subjected to elevated concentrations of phytotoxic and zootoxic air emissions eminating from coal-fired power plants or any other large stationary source.

2) Even if all air pollution abatement equipment of Colstrip Units 1 thru 4 perform at 100% expectancy of the designers' and manufacturers' predictions, there will be substantial tonnages of phytotoxic and zootoxic air pollutants emitted from these four units which will impact the ecosystems of the Colstrip area each year.

3) There are no field studies reported in the scientific literature which demonstrate that the air emissions of coal-fired power plants are beneficial to the health and growth of either plant or animal species.

4) While there is a dirth of available scientific literature on the biological effects of plant emissions, there is some evidence that these emissions have caused economic loss of agricultural and non-agricultural species of plants in various areas of the world.

5) The major phytotoxic pollutant emitted from coal-fired power plants is SO_2, and low concentrations of this gas in the ambient air cause visible and measurable damage to susceptible species of plants.

6) Anthropogenic SO_2 emissions have been accused by both European and United States scientists as being the main culprit for the increased acidic precipitation currently falling on large areas of Europe and the northeastern United States.

7) There are several other air pollutants emitted into the atmosphere from coal-fired power plants. These pollutants such as nitrogen oxides, fluorides, and heavy metals have the ability to singly and/or in combination with each other (including SO_2 emissions) cause visible and measurable adverse effects to the physical and biological portions of an ecosystem.

8) Several of the air pollutants emitted by coal-fired power plants are accumulated in tissues of flora and fauna species. The accumulation of these substances can occur over a period of several years in the long lived species and eventually cause a measurable change to the species diversity of an ecosystem.

9) There are numerous coal-fired power - plants either being proposed, designed, built, or going on-line in various areas of the United States because of the "need for energy" or for "project independence" on energy. The majority of these plants are being planned for agricultural areas rather than for urban or suburban areas.

10) There is currently an air pollution

problem in Billings, Montana, and the biological and physical environmental parameters of this area are similar enough to those of Colstrip that one can utilize the similarities in a comparison of the potential air pollution problem for Colstrip.

Nowhere in the scientific literature can one find the type of data which is needed to answer the environmental questions posed by the siting of 2,100 megawatts of coal-fired steam-electric power generation in the Colstrip area of Montana. The reasons for this are many, but primarily they revolve around the fact that the federal and state air pollution regulatory agencies have never dealt with baseline data gathering until after some of the large power plants went on-line in the southwest areas of the United States in the late 1960's and early 1970's. Those studies which were carried out by private utility companies and the Tennessee Valley Authority (TVA) prior to and after the installation of large and small power plants have rarely been released to the public. Thus, projections of the biological impact of Colstrip Units 1 through 4 emissions are based on numerous scientific articles and also previous investigations which had some similarities to the Colstrip project. However, it is fair to say that there are no two identical situations which can be compared absolutely so that one could predict with 100% accuracy what the short or long-term biological effects will be from the presence of phytotoxic gases being relased from stationary sources. This is primarily because of the measurable differences in terrain, meteorology, vegetation diversity, rainfall, and soil moisture from one area to the next.

There are some characteristics, however, when dealing with air pollution studies which hold fairly consistent regardless of the diversity of the above-mentioned factors between two or more physical and biological areas:

1) Coniferous species within a polluted area are almost invariably the first plants which visibly manifest symptoms because of toxic gases.

2) Plant species growing along ridge tops or on any elevated area of even fairly flat location will accumulate higher levels of the phytotoxic gases such as sulfur and fluoride than the same species of plants growing in the valleys, riparian areas, or depressions in a flat to rolling terrain.

3) With higher accumulation of these two phytotoxic substances death occurs to coniferous species growing on ridges and elevated terrain prior to the noticeable or visible death of any other species of plants or before the death of these same coniferous species growing in valleys or depressions.

4) At given ambient air levels for sulfur and fluoride compounds in both wet and dry climate areas, more visible damage occurs to the vegetation in the dry area than in the wet area. There is possibly an exception to this if one utilizes the SO_2 fumigation data obtained by Dr. Clyde Hill in the Four Corners area of New Mexico where there is eight inches of rainfall a year (Hill et al. 1974). However, this phenomenon has appeared very constant over both dry areas where the annual rainfall has always been at least 13 inches (Billings, Missoula, and Anaconda, Mon-

tana) and wet areas where there has been 50-60 inches of annual rainfall (Mt. Storm, West Virginia) (EPA 1971). In fact, during unseasonably dry years in wet or dry areas (Bellingham, Washington, and Columbia Falls and Garrison, Montana), there is a pronounced excess killing of vegetation over previous seasons when normal rainfall occurs.

5) Excess killing also occurs with the initial shock damage to the vegetation when a large stationary source of phytotoxic gases first goes on-line in a pristine area or an area where no detectable or only low amounts of pollutants were previously present (Hamburg and Stade, West Germany; Mt. Storm, West Virginia; and Garrison, Montana) (Gordon 1967-1972).

A. Acute and Chronic Damage to Vegetation: A Comparison

Two things which must be recognized are 1) the difference between acute and chronic types of vegetation air pollution damage and 2) the phenomenon of species selection and adaptability of plants growing and surviving in areas where air pollution has occurred for long periods of time. A good example of chronic vegetation damage in a seriously polluted area would be Anaconda, Montana, where vegetation which has survived in a 15-mile area around Anaconda manifests leaf burn on foliage only at or toward the end of the growing season, even though 28 tons of SO_2 are released each hour from the copper smelter located there (HES 1974).

If one compares this with the same chronic type damage to vegetation growing in a 5-mile radius around a low sulfur-emitting source (Hoerner Waldorf Pulp and Paper Mill, Missoula, Montana, 0.5 tons of H_2S and SO_2 per hour), one realizes the range of emissions which can cause chronic plant damage in areas which have had many years of excessive sulfur in the ambient air.

A good example of acute type damage is the serious plant damage, especially to conifers, in the Garrison area which occurred when the Rocky Mountain Phosphate plant went on-line in 1963. "Instant" vegetation damage was noticed in a seven mile radius around the plant in a one to three-month period and six to ten months prior to acute or chronic damage to animals (Gordon and Solberg 1964). Another example of this was in the Mt. Storm area of West Virginia and Maryland when the Virginia Electric and Power Company's Mount Storm steam plant (1,160 megawatt coal-fired generator) went on-line in 1967. Within 3 months, damage was observed in conifer species growing in the area. This was manifested by needle necrosis caused by gaseous pollutants and dwarfed needles caused by the increased acidic rains (EPA 1971).

This initial shock damage phenomenon which occurs with the introduction of phytotoxic gases in a relatively clean or pristine area relates to the Colstrip study area. In the Colstrip area, there has been continuous monitoring by personnel of the HES for various phytotoxic gases. The only one which seems to be present at continuously measurable levels is ozone, which averages 0.03 ppm or 0.05 ppm below federal ambient air standards (0.08 ppm).

The initial shock as far as acute damage to vegetation in the Colstrip area will occur when Unit 1 goes on-line in the summer of 1975. However, for comparison purposes, the major initial shock to vegetation from phytotoxic gases will occur in 1976 when both Units 1 and 2 are on-line. At that time, assuming that all abatement systems are operating at the efficiency levels stated in the Westinghouse impact statement (1973), the ambient air load of phytotoxic emissions around Colstrip will immediately take on the proportions which occurred in Billings, Montana, in 1970 (HES Implementation Plan 1971).

The instant or initial shock will first manifest itself in the form of acute necrotic damage on current-year needles of susceptible ponderosa pines growing on exposed ridges in the Colstrip area. This foliage together with other perennial plant species such as shrubs and grasses growing on exposed ridges will accumulate higher concentrations of fluoride and/or sulfur than the same plants growing on less exposed areas of valleys, depressions, or in the middle of thickly wooded areas.

1. Primary and Secondary Effects of Chronic and Acute Damage Caused by Fumigation on Vegetation

Acute damage to plant foliage is that which occurs from one or more high level fumigation episodes (Fumigation is herein defined as exposure to one or more pollutants of varying concentrations.) and is manifested by foliage symptoms of tissue necrosis in two days to three weeks. This type of fumigation usually occurs during adverse climatic conditions such as inversion periods or when strong winds bring the plume down to the surrounding terrain soon after it leaves the stack. Fumigation which causes acute foliar damage is a common-occurring phenomenon when large stationary emission sources first go on-line, unless the area has experienced long periods of previous fumigation. The susceptible species and varieties (sub-species of plants) within the area fumigated manifest acute type damage very rapidly and many can be partially to totally defoliated during a single growing season. If this high level fumigation continues intermittently during the entire growing season, serious long lasting plant damage can occur. However, this does not happen very often today with the advent of excessively high stacks and the location of stationary industrial sources in areas with good wind dispersion.

The loss (caused by fumigation) of portions or all of the foliage on stems of the susceptible plant species during the growing season will manifest itself by a loss of growth for that year. If acute fumigation damage occurs only occasionally, the plants usually recover normally as they do after a serious, unseasonable freeze or drought episode. If the acute foliage damage does occur consistently year after year for three to four years, susceptible perennial species will almost invariably succumb. With annual species of plants, acute fumigation damage can have a more severe effect upon the ecosystem than similar damage to perennials, since the total seed production in a given location could be destroyed if the fumigation occured prior to or during pollen or early seed development. From the standpoint of proving what caused the damage and how serious, both economically and environmentally, it is, the plant pathologist would prefer to deal with acute rather than chronic fumigation.

Chronic damage caused by air pollutants is that which is both invisible and visible to the investigators only after prolonged or intermittent periods of low level fumigation. Invisible injury means that only through physiological, cytological, and/or physical measurement can one determine the abnormal physiological or morphological change in the fumigated plant species. This chronic type plant damage is slow and insiduous, and measurable differences are necessary to quantify plant responses at chronic fumigation levels. For instance, if the photosynthetic rate of a given species of plant was reduced by 20% due to low level fumigation by O_3 and SO_2, the only time to measure this reduction or its consequences is either during the growing season with tedious respirometer measurements or at the end of the growing season by measuring the biomass of vegetation. The result of these tests then have to be compared with the results obtained from the same plant species growing in similar conditions but without phytotoxic gases. It is a laborious procedure, at best, and one which does not lend itself to evaluating the impact of pollutants on diverse species of flora and fauna in a polluted area.

Therefore, most investigation on chronic damage deals primarily with visible chronic damage. Examples of visible chronic damage to vegetation are:

1) Marginal leaf necrosis during the latter part of the active growing season.

2) Early leaf senescence of current year's growth.

3) A stress crop of an abnormally greater amount of seed production on certain species of plants.

4) Premature casting of coniferous needles.

5) Death and loss of species in an ecosystem over a period of many years.

Chronic damage can bring about such a slow, insiduous change to plant species and communities that trained investigators can overlook them or adapt to them unknowingly. For instance, in the northeast portions of the United States, eastern white pine is a fairly common species of conifer grown for horticultural and agricultural uses. Currently these pines growing in Maryland, West Virginia, and Pennsylvania are retaining one year's growth at the end of any given growing season with the previous year's growth casting in mid-July to early August as the new growth (current year's growth) matures (Gordon 1972b) When inspecting herbarium materials of white pines collected from these areas, one has to go back prior to 1925 to find that three years of needle retention was normal for the white pines during the early 1900's and late 1800's when the first white pine collections were made for herbarium preservation.

In some air pollution studies it has been suggested and even reported in the literature that portions of the major damage to or loss of susceptible plant species in air polluted areas is not entirely caused by either chronic or acute air pollution damage. Rather it is due to secondary causal agents which can be either abiotic or biotic in nature. For instance, a major causal agent of damage to coniferous species in The Dalles, Oregon, area is black pine scale which, under normal circumstances (in unpolluted areas), is a weak saprophyte insect that rarely causes severe plant damage (Compton et al. 1968). However, in this area, ponderosa pine trees have been severely weakened by 17 years of acute and chronic fluoride fumigation, and the insect has been able to establish a food base in them. Soon after an aluminum plant went on-line in The Dalles area, a black scale population surge developed which took on rather catastrophic proportions.

The same phenomenon of pine scale damage to ponderosa pine occurred around the Kaiser Aluminum plant 15 miles north of Spokane, Washington, where studies demonstrated a population surge on trees weakened by air pollution (Johnson 1950). Studies by Carlson et al. (1974) involving damaged conifers in the Flathead National Forest of Montana, also demostrated a massive insect infestation which occurred on weakened trees. Another similar study, again with coniferous species, was done by U.S. Forest Service plant pathologists in southern California. Here it was shown (Stark et al. 1968) that trees damaged by the Los Angeles photochemical oxidants in the San Bernadino Mountains were more susceptible to bark beetle infestations than the healthy conifers.

While most of the scientific literature which covers these secondary causal agents in air polluted areas concerns conifer species, there is no reason to assume that other plants are not weakened by air pollution damage and consequently affected by secondary causal agents.

11.1.5.2. Acid Rain Effects on Vegetation

A. Literature Review

This literature review is intended to present a general discussion of acid deposition by rainfall.

The first part concerns Swedish investigations which are of salient importance because the problems resulting from the acidification of Swedish precipitation were of sufficient magnitude to compel the Swedish government to prepare a case study on the phenomenon for the United Nations (UN) (Bolin 1971). A review of North American investigations into the phenomenon of acid rains follows. Also presented is a short discussion of some of the proposed mechanisms for the oxidation of atmospheric SO_2 to sulfate and sulfuric acid. This will be followed by an examination of some of the subsequent reactions and events which make quantitative studies of the acidity deposited in precipitation a difficult, and time-consuming endeavor.

In 1955, C. G. Roosby established a collection network for the study of precipitation which eventually covered most of northern Europe. Oden (1968) evaluated the data obtained by the network and emphasized the trends of decreasing precipitation pH and the increasing acidity of lakes and streams. He further pointed out a concomitant increase in the sulfate concentration in precipitation. These events precipitated the Swedish study of acid deposition by rainfall which resulted in Sweden's case study report for the UN (Bolin 1971).

This case study reports the result obtained in terms of the deposition rates of hydrogen and sulfate ions. These deposition rates and other considerations led the authors to conclude that the observed acidity was due to sulfuric acid which was formed from sulfur dioxide (Bolin 1971). In fact, since 1956 hydrogen ion concentrations in rain in certain parts of Sweden have increased by 200 times.

The real and potential biological, physical and ecological effects of this massive deposition of acid have compelled the Swedes to initiate many studies concerning acid rains. Of particular importance are those investigating the rates of deposition of sulfur and acid in precipitation as a function of distance from SO_2 sources (Hogstrom 1973, Granat and Radhe 1972); those aimed at characterizing the quantitative chemical characteristics of acid precipitation (Granat 1972b); and those involved in determining the biological effects and ecological implications of acid rain.

Unfortunately, in the United States little attention has been given to the phenomenon of acid rains. Likens and Bormann (1974) have discussed the American work. They report on the results of their research at the Hubbard-Brook Experimental Forest in New Hampshire, where the weighted means of pH samples collected weekly during 1970-1971 was 4.03. Precipitation at Ithaca, Aurora and Geneva, New York, showed weighted averages of pH at 3.98, 3.91 and 4.02, respectively. They further report that the hydrogen ion is the major cation, and that sulfate, chloride, and nitrate are the major anions at Ithaca and Hubbard-Brook. Likens and Borman (1974) report that no long-term record exists concerning precipitation acidity for the U. S. However, prior to 1940 no acid reactions were noted in precipitation with methyl orange, and prior to 1930, rainwater showed large amounts of bicarbonate alkalinity.

In Canada some important work is concerned with the effects of increased acidification of lakes on fish populations. For example, the acidity of many lakes in the vicinity of the Sudbury, Ontario smelters has increased by 100-fold during the last 10 years (Beamish and Harvey 1972). Some of these lakes have pH values of 4.5 and less, and are "critically acid" for fish survival.

The data from Sweden and the U. S. indicates that the phenomenon of acid precipitation is a relatively recent event of the last 20-30 years and parallels increased atmospheric injections of SO_2 on a regional scale. The data from Canada may indicate that acidic precipitation has been a local environmental problem for some period of time, and could have been compounded recently by regional influences.

How does naturally occurring precipitation become acidic? "Normal" pure rainwater has a pH value in the range 5.5-5.7 due to the dissolution of carbon dioxide in water and hence is slightly acidic. The presence of any sulfur dioxide (SO_2) in the atmosphere will decrease the pH (increase the hydrogen ion concentration) of rainwater because it is soluble in water and forms sulfurous acid (H_2SO_3). This acid dissociates in two stages to produce hydrogen ions. In polluted atmospheres this dissociation is significant and contributes to the hydrogen ion concentration of the rainwater (Anon. 1973). Additionally, atmospheric sulfur dioxide can be oxidized to sulfate or to sulfuric acid through several proposed mechanisms.

It will be of value at this point to introduce some of the proposed mechanisms involving sulfur dioxide which result in acids and/or sulfate. These reactions should be viewed in light of their potential relative contributions to atmospheric acid rather than singling out any particular mechanism as the most significant. However, certain reactions may be more important than others, depending on atmospheric conditions and time (Anon. 1973).

1) Direct photo-oxidation of SO_2. The "Clean Air Mechanism".

$$SO_2 \xrightarrow[O_2]{\text{light}} SO_3$$

$$SO_3 + H_2O \longrightarrow H_2SO_4$$

This reaction is slow, but may be important in the long-range transport of SO_2 (Anon. 1973).

2) Indirect photo-oxidation. The "Dirty Air Mechanism".

$$SO_2 \xrightarrow[\text{oxygenated free radicals}]{\text{smog}} SO_3$$

$$H_2O + SO_3 \longrightarrow H_2SO_4$$

This reaction is fast. The amount of $SO_4^=$ formed depends more on the oxygenated free radical concentration than on the SO_2 concentration (Anon. 1973).

3) Air oxidation in the condensed phase. The "Clean Water Mechanism".

$$SO_2 \xrightarrow[H_2O]{\text{liquid}} H_2SO_3,\ H^+,\ HSO_3^-,\ SO_3^=$$

$$NH_3 + HSO_3^- \longrightarrow NH_4^+ + SO_3^=$$

$$SO_3^= \xrightarrow[O_2]{\text{liquid } H_2O} SO_4^=$$

This reaction may occur in water droplets or on the surface of aerosol particles (Anon. 1973).

4) Catalytic oxidation in the condensed phase. The "Dirty Water Mechanism".

$$SO_2 \xrightarrow[\text{heavy metal cations}]{\text{liquid } H_2O} SO_4^=$$

As previously mentioned, Mechanism 1 may be important only on a global scale while mechanisms 2, 3 and 4 may be important on both local and global scales.

Sulfuric acid is very soluble in water and is virtually completely dissociated. It has been hypothesized that the pH of rain near sources of pollution may be controlled by SO_2/H_2SO_3, while at greater distances from the source, the pH of rainwater may well be controlled by H_2SO_4(Bolin 1971). Additionally, the oxidation products of the oxides of nitrogen (NO_X) may contribute to the acidification of precipitation. Hydrofluoric acid (HF) may also be locally important.

It can be seen from the above mechanisms that many oxidation and neutralization reactions involving SO_2 are possible. Further reactions resulting in sulfate salts are known to occur. When one considers that NO_X , HCl, and HF are possible contributors to the acidity of precipitation, one can appreciate the statement by Granat (1972b):

> "The pH in precipitation is thus determined by several compounds of different origin. It is thus not surprising that the relation between one element (sulfate) and pH has a correlation coefficient which is not significantly different from zero."

To continue with this theme, it must be borne in mind that deposition by precipitation is only one of several mechanisms whereby excess acid and sulfur are removed from the atmosphere. Other mechanisms include sedimentation, aerosol removal by vegetation, gas removal by vegetation, and the sorption of gas particles. To complicate matters, the re-emission of gases and the re-suspension of deposited particles are possible (Granat 1972a). Finally, the interaction of "normal" precipitation with acids deposited by dry fallout or sorption in causing biological damage has yet to be investigated.

Even as Granat is not surprised at the lack of correlation between sulfate and pH, a lack of correlation between vegetaion damage and acidity in precipitation is also not surprising. Particularly when one deals with a point source of SO_2, this lack of correlation may be expected since, although precipitation may be one of the more important mechanisms for the deposition of atmospheric acid and sulfur, it is by no means the only one.

During the last 4½ years, an in-depth series of field and laboratory studies have been conducted on tissue damage and necrosis in basal areas of coniferous needles caused by acidic rain water or prepared acidic solutions (Gordon unpub.). These studies can be broken down into four categories which will help the reader more fully understand this complicated and serious problem:

1) Host Species and Host Tissues

2) Causal Agents and Synergistic Effects

3) Early Detection of Damage

4) Late Detection of Damage

1. Host Species and Host Tissues

No other species of plants have been more utilized in biological monitoring of air pollution damage than pine. The primary reasons for this are:

1) Species within this genus have proven to be extremely susceptible to many of the known phytotoxic gases released into the ambient air.

2) One or more species of pines are indigenous to, or horticulturally grown in, almost all geographical areas of the northern hemisphere.

3) The pines are a more primitive plant group than any species of angiosperms by at least 30 million years (Alvin 1960) and have a complex tissue morphology in comparison to angiosperms.

Because of this early evolution, some of the species within the genus pine have had ample time to evolve and adapt to almost all types of environmental conditions found in the northern hemisphere. Also, they have needle growth ontogeny patterns which can be referred to as their Achilles heel when coming in contact with airborne acidic precipitation or acid solutions. This Achilles heel area of the needle structure is the meristem area located at the base of the needle where it is attached to the stem. This is the only meristem area of the needle during its lifetime.

The meristem area of the pine needle is only active as a somatic reproductive area for a 2 to $2\frac{1}{2}$-month period during and after needle emergence and is protected during this time by a fascicular sheath which is comprised of several layers of thin-walled parenchymatous cells (also known as cataphylls). As the cells are produced by the intercalary meristem in the basal area of the emerging needle, the older apical cells and tissues are pushed out past the fascicular sheath and exposed to the ambient air. Prior to this time, a cuticle is formed over the outside of the epidermal cells, protecting them, as well as other types of needle cells (i.e., hypodermis and mesophyll cells), from environmental conditions such as wind, rain, and insect and fungal attack. However, most basal cells of the developing needles covered by the fascicular sheath do not form a cuticle until all meristematic activity, and thus all growth of the needle, ceases.

The period of time from needle emergence (from the original bud sheath) to full needle length development is approximately 2 to $2\frac{1}{2}$ months, depending on species and weather conditions. Thus, the period when no cuticle is present in most basal cells beneath the fascicular sheath can be up to a period of $2\frac{1}{2}$ to 3 months. Even after these basal epidermal cells do produce a cuticle on their outer cell surface, it is much thinner than the cuticle formed by the more apical epidermal cells located beyond the fascicular sheath. It is this lack of cuticular formation on these basal epidermal cells beneath the fascicular sheaths during the early developmental stage ($2\frac{1}{2}$ to 3 months) as well as the thinner cuticle which does finally form after full needle elongation and development, which causes this area to be so vulnerable.

One other factor adds to the seriousness of the meristem vulnerability when the causal agent of potential damage is carried by rain water. This is the fascicular sheath itself, since in its morphology it is similar to a long thin vase attached to the most basal cells of the needles and open in the apical area to allow for needle emergence. This vase-like structure allows for the collection of dew and rain water which does not dissipate or run off as rapidly as it does on the epidermal tissues of the much larger portion of the needle not surrounded by the fascicular sheath.

2. Causal Agents and Synergistic Effects

From studies carried out by personnel of the University of Montana Environmental Studies laboratory as well as Dr. Bormann's laboratory (1973), it has been established that inoculations of needle and leaf tissues with acid solutions at various pH levels will cause cellular and tissue damage. The pH levels thus far established as sufficient to cause damage have been with three different acids. These are H_2SO_4, H_2NO_3, and $HF \cdot H_2O$, the first two being strong acids and the latter being a weak acid. It should be noted, however, that because an acid such as hydrofluoric acid is termed weak, it does not necessarily infer that it takes more acid solution or even a solution with a more acidic pH to cause damage to plant tissue. In fact, just the opposite is true. For instance, in earlier studies (Gordon 1972a), it was discovered that a hydrofluoric acid solution with a pH value of 5.5 would cause damage to the basal tissues of young emerging pine needles when applied at 10 drops per day for a 15-day period. When using Sulfuric acid (a strong acid) in the same amount (10 drops per day) and for the same length of time, it took solutions with a pH value of 4.0 to cause similar tissue damage. Therefore, regardless of the terminology given to certain acids because of their chemical properties of disassociation, it should be recognized that a strong acid can cause damage to certain plant tissues in a much less concentrated form than a weak acid.

Table 11-16 illustrates the concentrations of sulfate, fluoride, and hydrogen ions which would be present in six different solutions of H_2SO_4 and $HF \cdot H_2O$. As can be ascertained from this data, a pH value in the range which has been shown to cause damage to the basal tissues of young emerging pine needles (pH 4.5 for H_2SO_4 and 5.5 for $HF \cdot H_2O$) will result in a very small concentration of these anions. It is the hydrogen ion which has been established as that portion of the acid which causes plant tissue damage. However the acid, itself, is the result of the HF which is generated during the combustion of coal or the subsequent oxidation of the NO_x and SO_2 which are also generated during coal combustion. Clearly, without the HF, NO_x or SO_2, there would be no anthropogenic acid, and it follows that the mechanism to be employed to control acid rain is to control stack emissions.

A point which should be emphasized concerns the residence time of SO_2 in the ambient air from the time it leaves its stationary source until it falls out or is washed out of the ambient air. Probably the largest amount of scientific investigation and data accumulated on the residence time of SO_2 in the ambient air has been from the Swedish scientists who have worked on precipitation chemistry since 1952 in Sweden and other northern European countries. These scientists (Oden et al.) have established that SO_2 can remain in the atmosphere for two to four days and travel over 1,000 kilometers (600 miles) during residence time in the ambient air.

A second point of emphasis regards the oxidation of SO_2 to sulfate in the atmosphere. Many excellent articles by both American and European scientists are included in the scientific literature concerning the chemistry of this conversion (oxidation) of SO_2 to sulfate. The conversion by oxidation may be rather rapid and in a period of 17 to 20 hours from the time it is emitted, over 50% of the SO_2 still in the atmosphere may be oxidized to sulfate. This has several variables, however, since the rate of oxidation is partially regulated and is affected by the presence of particulate matter, aerosols, and the H_2O concentrations in the atmosphere. However, for the purpose of this report, it should suffice to know that it is scientifically established that:

1) SO_2 will convert to sulfate in the atmosphere (Anon. 1973).

2) SO_2 and sulfate have the physical abiliity to be carried long distances from their

TABLE 11-16

Concentration of $SO_4^=$ and F^- as a Function of pH in Pure Aqueous Solutions of Hydrofluoric and Sulfuric Acids

pH	Hydrogen Ion Concentration in Moles/Liter	ppm $SO_4^=$
3.01	9.77×10^{-4}	45.7
3.40	3.98×10^{-4}	18.8
4.00	1.0×10^{-4}	4.7
4.69	2.04×10^{-5}	0.95
5.00	9.99×10^{-6}	0.47
5.39	4.07×10^{-6}	0.19

pH	Hydrogen Ion Concentration in Moles/Liter	ppm F^-
3.05	8.91×10^{-4}	16.6
3.54	2.88×10^{-4}	5.36
4.09	8.12×10^{-5}	1.52
4.54	2.88×10^{-5}	0.54
5.00	9.99×10^{-6}	0.18
5.52	3.01×10^{-6}	0.05

emission sources (Bolin 1971).

3) SO_2 can be oxidized to sulfuric acid in the atmosphere and during precipitation washout, can impact the physical and biological systems of the earth.

4) Several studies have demonstrated that rain water which falls in the spring and summer is more acidic than rainfall in the winter months (Likens 1974). This means that during the most susceptible period of the plant's life cycle (early developing stages of vegetative and reproductive tissues), acidic rains are more prevalent than during the dormant periods of the plant's life cycle.

3. Early Detection of Damage

Most University of Montana, Environmental Studies laboratory and field studies with acid solutions as well as Bormann's studies have employed young developing leaf or needle tissues. These young tissues respond very rapidly (5 to 30 days) to acid solutions of either H_2SO_4 and/or $HF \cdot H_2O$ with pH values ranging from 1.5 to 4.5. The response in conifer needle tissues is the cessation of meristem activity in the basal areas causing the needles to be dwarfed or to abort and be prematurely cast from the branch. Wood et al 1972) using H_2SO_4 with a pH value of 3.0, obtained spot necrosis and abnormal development of leaf tissues from developing birch leaves in his inoculation studies with young seedlings.

Other acid inoculation studies yet unpublished by B.A. Kratky as cited by Likens (1974) working in Hawaii demonstrated that pollen germination was decreased and pollen tube growth was reduced in tomato plants. Ferenbaugh's studies (1974) on H_2SO_4 solution inoculation of bush bean (Phaesolus vulgaris) demonstrated that at pH levels of 3.5 and lower, photosynthesis rates increased, starch formation and accumulation decreased, cells of leaf tissues were smaller, excessive adventitious building occurred, and growth of plants was severely retarded. His studies, likewise were carried out on young, developing plant tissues.

Again, all of these studies showed early damage (within 30 days) after the acid inoculations were begun on the plant tissues. Also, it should be pointed out that most of the investigators mentioned here used acid solutions which were not buffered by any compounds or substances, and thus were pure even though dilute acid solutions.

The only scientifically proven case of early acid rain damage to plant tissues which is known to occur in nature is the dwarfing of developing pine needles in areas which have large stationary sources of SO_2 and/or HF emissions (Gordon 1972b). In general, however, most acid rain damage to plant tissues occurs over a long period of time (one growing season or more) and is slow and insiduous, thus making it more difficult to evaluate. When early acid-caused damage is detected in plants, it appears from studies done that damage will be found on those leaf and reproductive tissues developed during the early portion of the growing season.

4. Late Detection of Damage

Late detection of damage basically means that the tissue or metabolic function damage caused by the acidic rains manifests itself only after prolonged periods of time such as at the end of the first growing season up to several growing seasons. Examples of this type of damage would be a reduction of the total crop weight from the previously "normal" crop weight or in other words, a reduction in the biomass of the vegetation (food source) growing indigenously in an area or propagated by man.

At present there is no scientific work which demonstrates that acidic precipitation has caused a reduction of the biomass of any food crop propagated by man. Therefore, the only available data which deals with late detection of acid rain damage comes from studies on premature casting of conifer needle foliage to cultivated and indigenous species of pine (Gordon unpub.). These studies, which were carried out in the northeastern area of the U.S. (Maryland, West Virginia and Pennsylvania); in areas around Little Rock, Arkansas; The Dalles, Oregon; Ferndale, Washington; Columbia Falls, Anaconda, East Helena, Missoula, Garrison and Billings, Montana; as well as Hamburg, Germany, were all in areas where large stationary sources were emitting either H_2S, HF, and/or SO_2 into the atmosphere.

The late detection symptom manifested by the conifer vegetation in these areas was the premature casting of older needles ahead of their normal attrition period. To understand this, one must recognize that species of pine retain a given number of years' foliar growth. This time retention of needles for any given species or the differences between species is dependent upon several environmental factors such as annual rainfall, site and slope where trees are growing, etc., but rarely varies more than one year less or one year more from the normal needle retention of the species. For instance, normal needle retention time for ponderosa pine in the Colstrip area is five years, while in the Missoula and Potomac Valleys it is four years. Both areas have somewhat similar climate and rainfall, and the difference in the one-year needle retention has been attributed to soil moisture retention during the growing season. In rather severely air polluted areas in a 10 to 15 mile radius around the Anaconda copper smelter and East Helena lead smelter, ponderosa pine retain two to three years of needle growth. At further distances (up to 30 miles away) three to four years of needle retention is not uncommon. However, four years is believed to be average for ponderosa pine.

The retention of a normal compliment of needles to a coniferous tree is needed for the realization of normal food production, and thus annual growth. As this retention is reduced, food production and annual growth are in turn reduced.

Premature needle casting of portions or all of the older needles (third to fifth year growth) is not uncommon in areas where severe air pollution problems occur. For instance, in a four-mile radius around the Corette power plant in Billings, Montana, ponderosa pines are retaining two to three years of needle growth; in Columbia Falls, Montana, many of the ponderosa pine are retaining one to two years of needle growth; and in large portions of West Virginia, Pennsylvania, and Maryland, eastern white pine and Scotch pine are retaining one to two years of growth. These later two species of pines should retain three years of foliar growth.

The cause of this premature casting is a question that plant pathologist have been working on for some time in air polluted areas. A portion of the loss of normal needle retention was known to be the result of continuously increased needle tip burn which progressed back to the point of needle attachment with the continuing advent of fumigation by one or more toxic gases. However, needle tip burn was usually not severe enough in most air polluted areas, except in the immediate vicinity of the polluting source(s), to cause severe needle loss. At further distances from the polluting source, however, the cause of premature casting had to be different because of the lack of tip burn. The answer became clearer when investigators started looking at the basal or fascicular areas of the older green needles. In this area beneath the fascicular sheath was found tissue necrosis which macroscopically resembled tissue necrosis in dwarfed needles caused by acid rains in the field and acid solutions from controlled inoculation tests. Histological studies of this older needle tissue disclosed that the pathology was identicical to what was found on dwarfed needles from the field and laboratory studies (Gordon 1972a).

Thus, even though the acidic rains were either not present or not acidic enough to cause dwarfing during early needle development, in the ensuing periods of time after full needle development, the basal tissues had been damaged by acidic rains. It is not known at what pH the precipitation has to be to cause this slow (one to three years) necrosis which leads to premature casting, but it obviously is above 4 to 4.5 pH since these levels are known to cause needle dwarfing or early detection.

The above information on needle growth, needle retention, and basal needle necrosis has been explained rather laboriously because this type of acid rain damage had not been recognized until recently. There are many reasons why this late detection type of pine foliage damage went unnoticed, but only the major reasons are presented here. First, the tissue necrosis of the needle is hidden by the fascicular sheath. Second, at long distances from polluting sources pathologists were looking for needle tip burn associated with premature casting. This was not occurring. Third, this damage occurs slowly to the needle bases (one to three or four years) and thus is difficult to discern unless histological studies are carried out, and they weren't until 1972.

The information presented in this section is applied as follows to the baseline data collected in eastern Montana. At one of the 35 sampling sites, Site SE5 (see Figure 10-24) which is located 79 miles southeast of Colstrip, ponderosa pine foliage manifesting tip burn on the third to fifth year needles (which macroscopically resembled typical air pollution type damage) was collected during the fall of 1973. During this same time similar needle tip burn was found on ponderosa pine foliage growing one mile southwest of Miles City. Histological studies of these necrotic needles revealed a tissue pathology which was caused by SO_2.

Because of this discovery, during the spring field collection period for this study in 1974 special notice was taken of the ponderosa pine foliage collected from Site SE5 as well as several other sites. Fascicles were removed from the current and older needles of a portion of the pine samples and basal tissue necrosis was present on 1970 to 1973 needles. Necrotic basal tissues which had been collected from six sites were selected for histological studies (see Table 11-17). These studies revealed that the tissue pathology of those ponderosa pine needles selected was identical to that obtained from the sulfur and/or fluoride polluted Montana areas of Billings, Anaconda, East Helena, Columbia Falls, and Missoula, as well as that occurring in the northeast portion of the United States. Also, the tissue pathology was identical to that obtained with known concentrations of H_2SO_4 acid solutions in greenhouse inoculation studies at the University of Montana from 1971 to 1974 (Gordon unpub.).

The six photographs which follow (Figures 11-14 through 11-19) illustrate acid rain damaged vegetation as well as examples of healthy vegetation tissues. Figure 11-14 shows short-long needle damage to lodgepole pine collected near Columbia Falls, Montana. Acid burnt 1973 ponderosa pine needles collected in the spring of 1974 near East Helena are shown in Figure 11-15. Figures 11-16 and 11-17 illustrate acid rain damaged lodgepole pine tissue and healthy ponderosa pine needle tissue, respectively. Damaged and healthy ponderosa pine basal tissues are shown in Figures 11-18 and 11-19, respectively.

5. Discussion of Results

The environmental problems and ecological consequences of acidic rains to the animate and inanimate portions of the earth are just starting, (in the last 20 years) to be realized. There are so many fundamental questions concerning even the physical and chemical properties of acidic precipitation yet unanswered that one soon realizes it will be many years in the future before the biologist can, with scientific evidence, predict the types of impact to the environment from acid rains. However, regardless of the scarcity of scientific information and data now available on this subject, the following evaluation of the potential impact of the new air emissions from the Colstrip power plants in relationship to increased acidity of precipitation is presented. This evaluation will be aided by presentation of information obtained on this subject during the past year.

B. Precipitation Chemistry

Section 10.1.3.3. of this report presents precipitation chemistry data obtained from rain water samples from the Colstrip area as well as three other seriously air polluted locations. As can be ascertained from Table 10-31 in Section 10.1.3.3., the high, low and average pH values found in Colstrip rain water were not greatly different from those obtained in a 30-mile vicinity around the Anaconda and East Helena nonferrous smelters. If, however, one compares the data from rain water collected in the Mt. Storm area of West Virginia and Maryland with data from the three Montana sites, one discerns that there is almost a 100-fold increase in hydrogen ion concentration in the Mt. Storm area as reflected in the average pH values and at least a 10-fold increase in acidity as reflected by the low pH values obtained. Sulfate values presented in Table 10-31 also disclose that at the three study areas where sulfate analysis was completed, the average values were very similar as were the high and

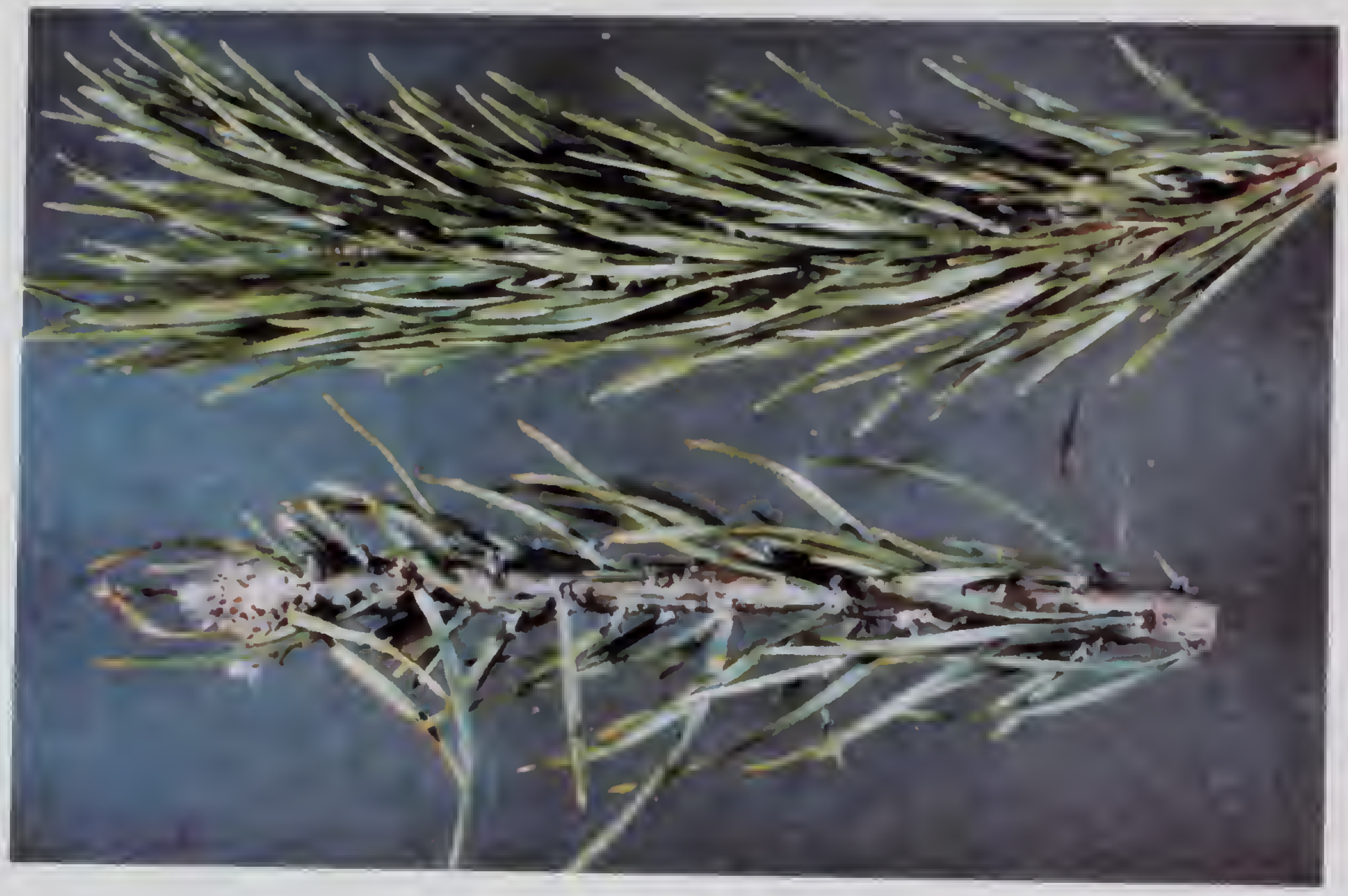
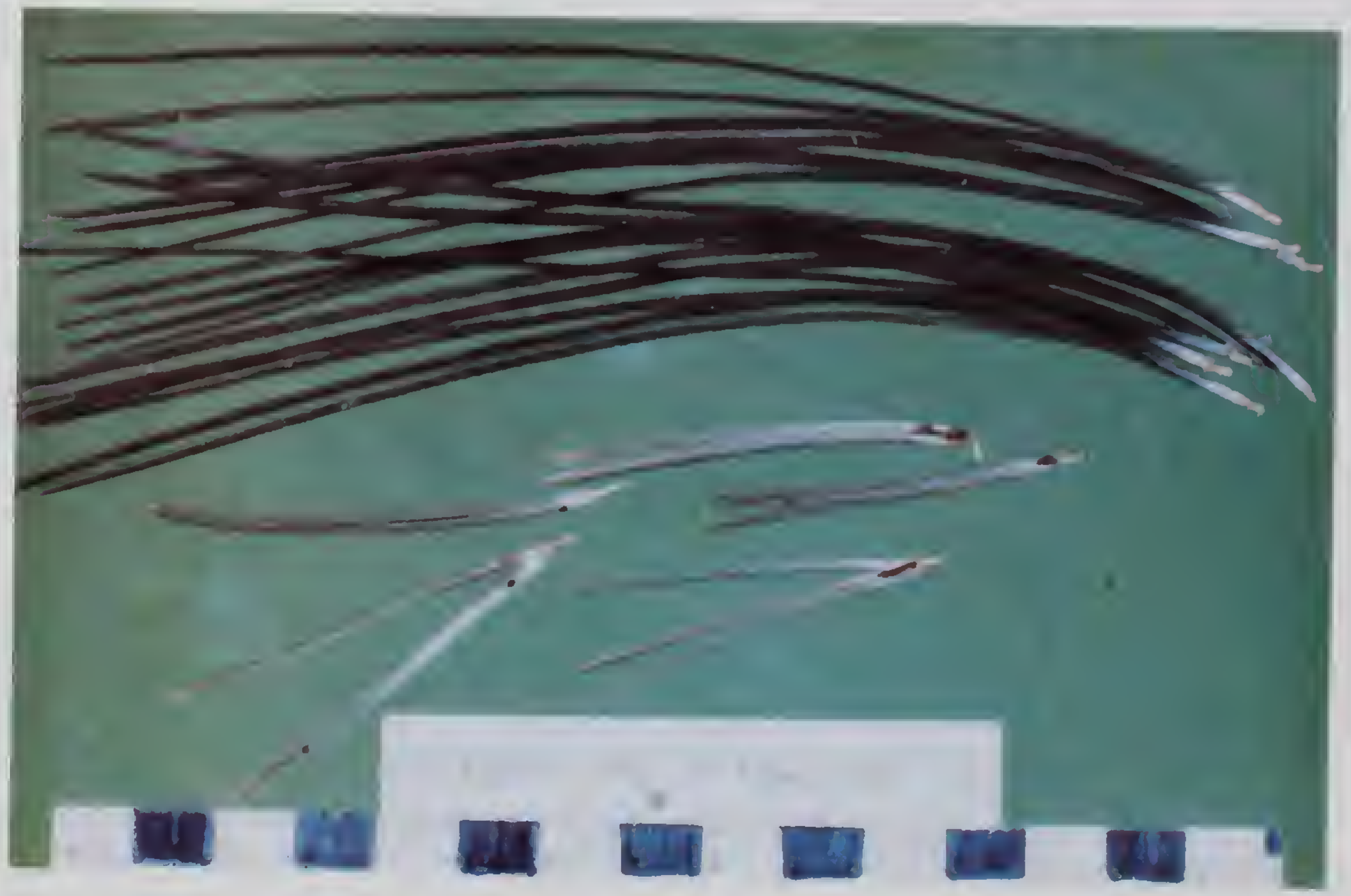


Figure 11-14

Scotch pine branches which depict the short-long needle syndrome (or early acid rain damage) on the branch on the bottom in comparison to the healthy Scotch pine branch and needles on the top. Materials from the Mt. Storm area of West Virginia.

Figure 11-15

Acid burnt 1971 needles of ponderosa pine collected 25 miles from the ASARCO plant at East Helena. These are dwarfed needles (short-long needle syndrome) in comparison to healthy needles in the photograph.



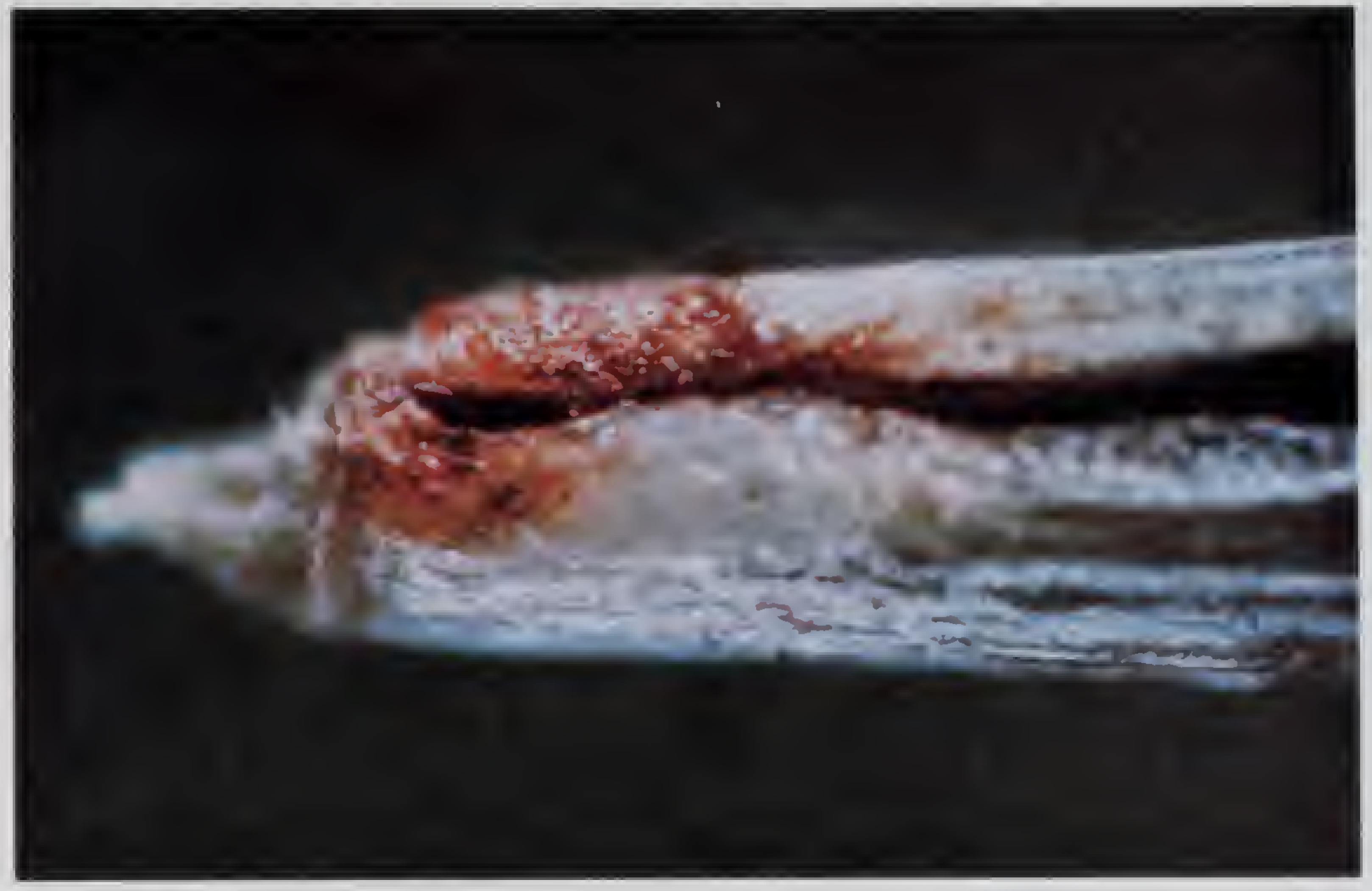
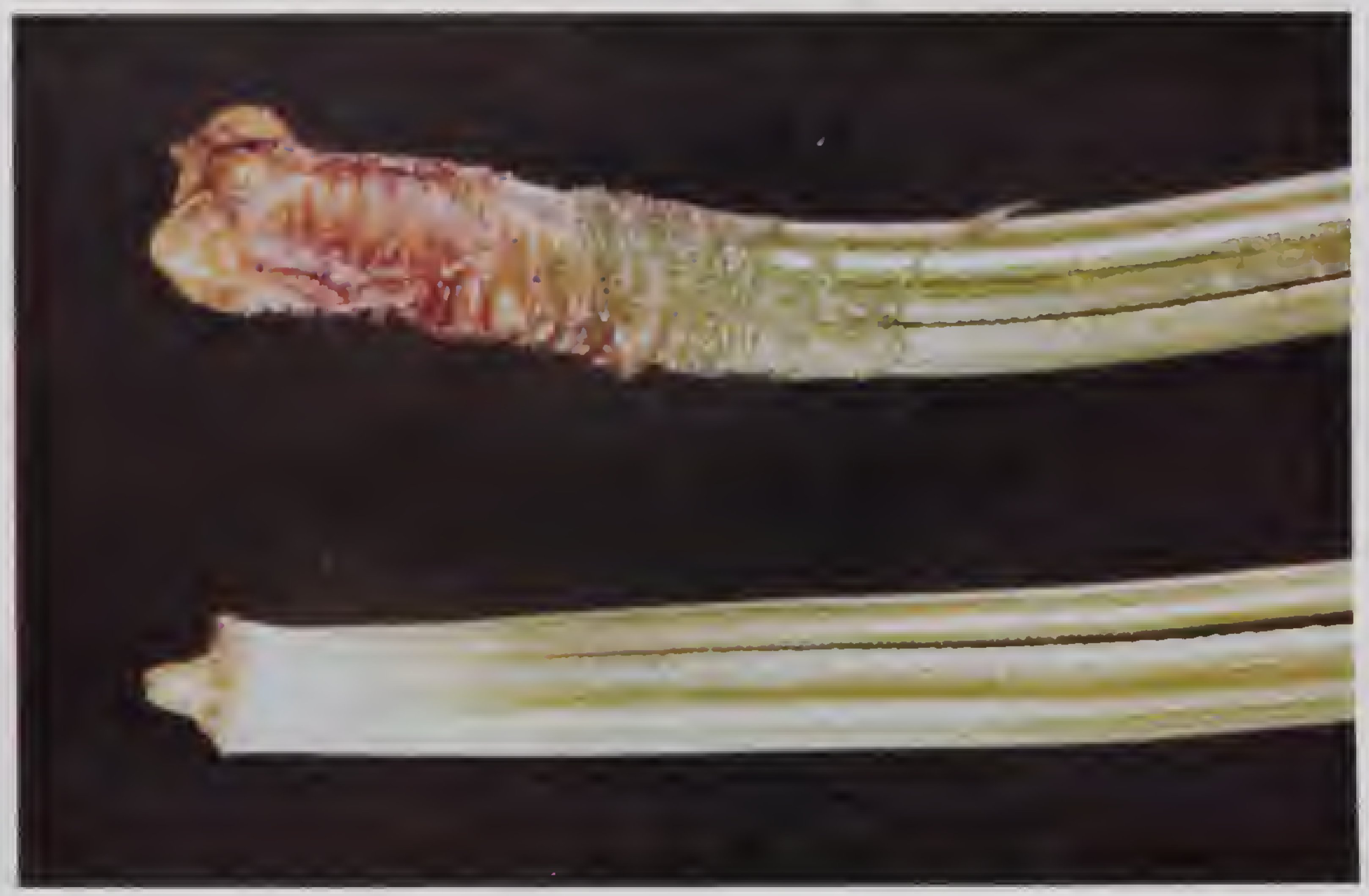


Figure 11-16

Longitudinal section of dwarfed lodgepole pine needle from Sleeping Child Drainage showing basal tissue damage caused by acid rain.

Figure 11-17

Photographic comparison of one healthy ponderosa pine basal area and one damaged by acid rain.



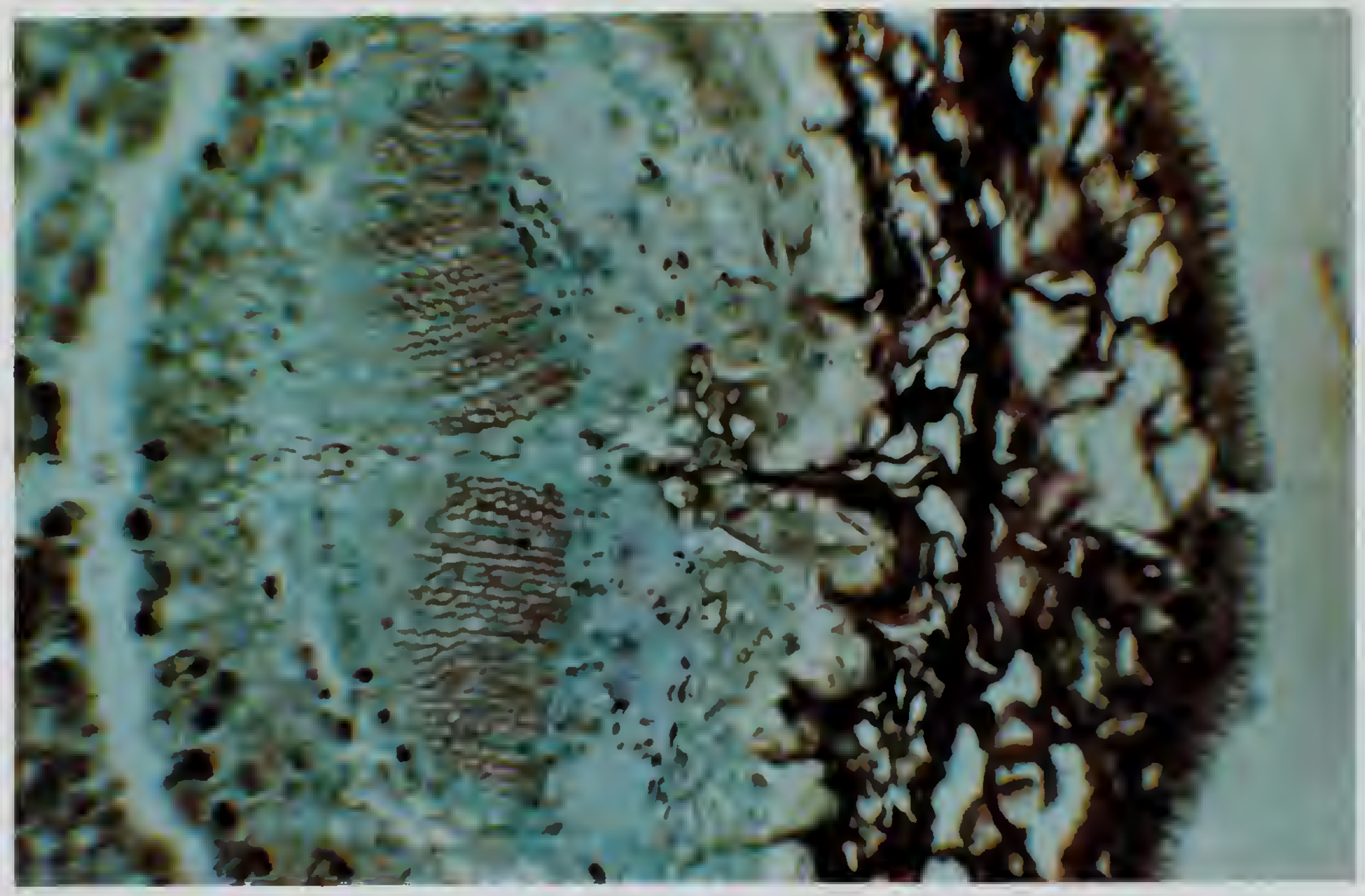
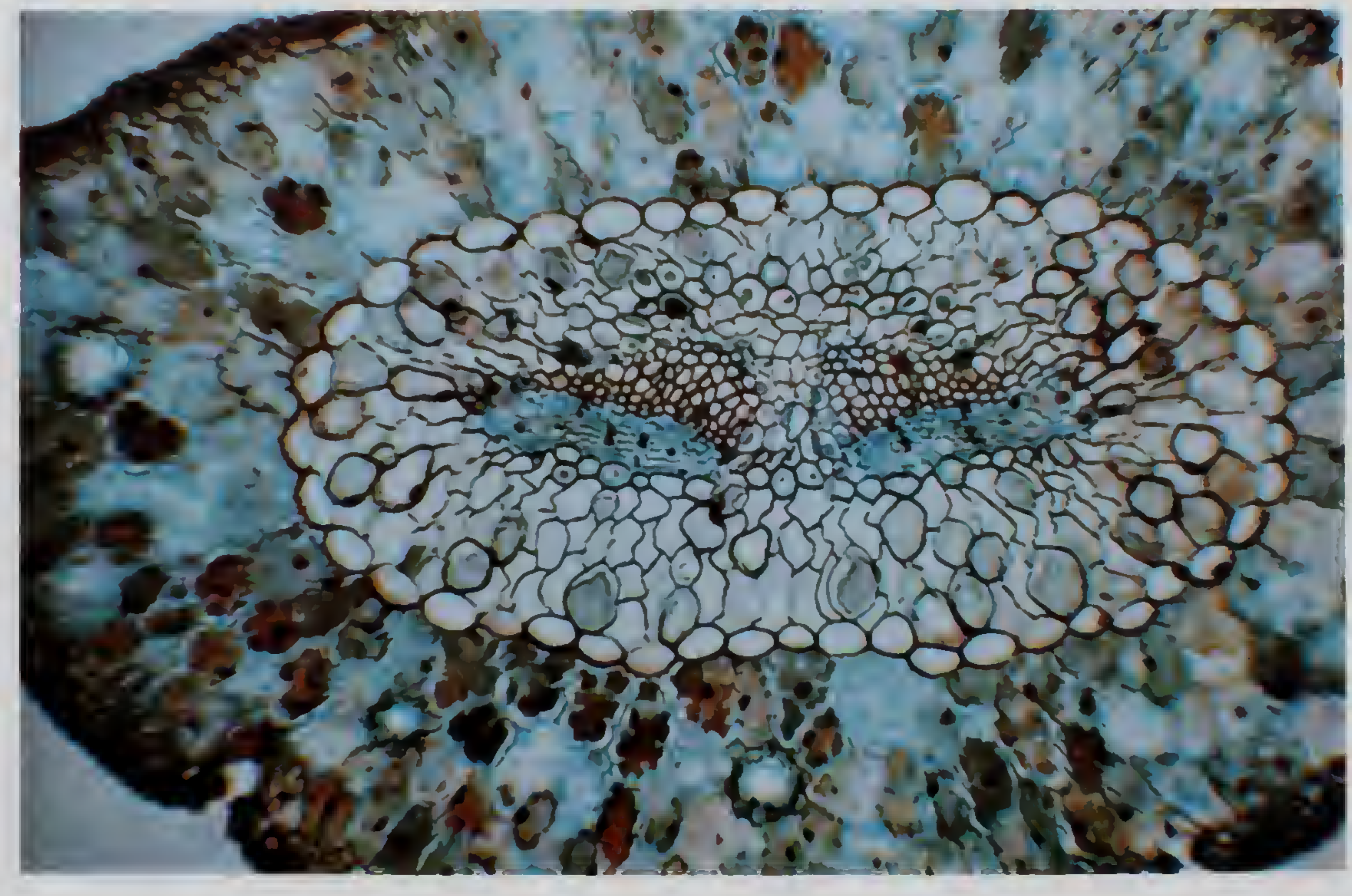


Figure 11-18

Cross section of the basal tissue of 1973 ponderosa pine needles damaged by acid rain at Colstrip collecting site E3.

Figure 11-19

Cross-section of healthy ponderosa pine needle depicting normal cellular arrangement.



low values obtained. Excepting the weaknesses of the current methodologies utilized in precipitation collection at all four study areas listed in Table 10-31 as well as the time lapse factor between rainfall periods and chemical and physical analysis time, the only study area which is significantly different from the others as far as precipitation chemistry is concerned is the Mt. Storm area.

C. Acid Damage to Pines

Concerning tree damage in all four areas, Mt. Storm is also significantly different in that severe dwarfing of needles (early detection) is prevalent throughout the area in three species of pine (Scotch pine, Eastern white pine and Virginia pine). In Anaconda and East Helena, dwarfing of pine needles (ponderosa pine, limber pine and lodgepole pine) caused by acid rains has been found, but it is not as prevalent as the late detection type of acid rain damage to the older, normal-length green needles. The growth and health of pine trees in Anaconda, East Helena, and Mt. Storm have been documented as decreased and diseased, respectively, by air pollution studies over the past years (Gordon unpubl.), while those pines growing in the Colstrip area were considered, during the initiation of this study, to be normal and healthy. Because of the findings from histological studies of necrotic pine needle bases collected at six sites in the Colstrip area, it is obvious that what seemed to be "normal" trees in the Colstrip area are actually damaged trees. While the severity of damage to these ponderosa pines is minute in comparison to that found in pine trees from the Anaconda, East Helena, and Mt. Storm areas, from the point of view of plant pathology, they definitely are damaged.

Although previously stated, it should be emphasized (since it is the basis for any prediction which can be made concerning the consequences of further increased acidity of precipitation in the Colstrip area) that the pine species, and especially specific species such as ponderosa pine, are extraordinary indicators for detecting the presence of many phytotoxic materials in the atmosphere. In the case of acidic precipitation, no other species of plant has been found to date which is damaged as visibly or severely as are several species of the genus pine. While it is possible that acidic precipitation may at even higher pH levels (approaching a pH of 7) cause damage to other living organisms or cause slow and insiduous leaching of nutrients from the soils or even cause lake waters to become acidic, there is no scientific evidence at this time to quantify or qualify that assumption. Therefore, the only pine species prevalent in the Colstrip area (ponderosa pine), which happens to be extremely susceptible, was utilized as the indicator for precicting future impact from added emissions of Units 1 through 4. Because a prediction is made of what the possible impact could be to these pine trees, some prediction must also be made concerning the origin of current acid rains. This is necessary because any phytotoxic emissions from increased industrialization will be added to those current levels and to the increased levels which will be present when Units 1 and 2 are operational. Therefore, Table 11-17 shows distances between six sites having acid-damaged needles and some of the stationary industrial sources of gaseous emissions which could result in the presence of strong acids in rain water.

As Table 11-17 shows, some of the sites (Site SE5 and NE3) are 110 to 154 miles from the closest SO_2, NO_x and HF large stationary sources.

TABLE 11-17

DISTANCE OF COLSTRIP SAMPLING SITES* FROM NEAREST KNOWN SO_2 SOURCES

		Distance in miles from Collection Sites:				
Ponderosa Pine Collection #	Collection Site #	Colstrip	Billings	Gillette	Sidney	Anaconda
F 2025	SE 1	6	98	100	184	314
F 2029	SE 5	79	174	110	154	390
F 2050	S 4	40	96	94	201	313
F 2056	NE 3	20	104	132	154	320
F 2078	E 3	20	104	118	162	324
F 2113	W 3	20	76	136	184	314

*See Figure 10-25 for sampling site locations

Unfortunately, an inventory of the total phytotoxic emissions from these sources is not available. Also, unknown is whether all of the sources or only certain ones are contributors to the acidity of precipitation which has caused the current damage to ponderosa pines near Colstrip. However, it is known that several other large coal-fired generating sources of SO_2, NO_X and HF are considered for eastern Montana and Wyoming besides potential increased expansion in the area of Billings, Montana. The prediction becomes more difficult if the Swedish data on residence time of SO_2 in the ambient air is used, which requires that all possible SO_2 sources within a 600-mile area of the six sites must be considered contributors of acid rain damage to the pine trees. This would include all sources east of Moses Lake, Washington; all sources south of Calgary, Alberta; all sources west of St. Cloud, Minnesota; and all sources north of Colorado's southern border, with Colstrip as the center of the 600-mile circle.

As one can easily discern, SO_2 sources in the territory that must be explored as potentially contributing to the current damage are staggering. If other emission data (presented in the Draft Environmental Impact Statement for the Eastern Powder River Coal Basin, page I-464 and I-465, tables 1 and 2, Volume II), is added to this assessment, then there is some certainty in predicting that the acidity of the rain water will not decrease in the Colstrip study area even in the absence of Units 1 and 2.

D. Conclusions

It is assumed that Colstrip generating Units 1 and 2 will potentially emit 2,200 tons of SO_2 and 1,472 tons of NO_X monthly into the atmosphere at Colstrip (Westinghouse 1973). A portion of these gaseous emissions will directly cause an impact upon the vegetation and result in some damage. A portion of these gaseous emissions will be converted to acids in the atmosphere and increase the damage to conifer needles at greater distances from Colstrip than will the SO_2 and NO_X gases emitted by the two units. From current data concerning acid rain damage to ponderosa pine foliage in the study area, the only possible conclusion is that an increase in acidity of rain water will occur from these added emissions. The seriousness of the damage can be determined by the presence of early detection type symptoms (dwarfing of needles). The geographical extent of the area affected by this increased acidity in rain water can be determined by the advent of a one to two year reduction in the normal five year complement of needles retained in the area. The larger generating Units 3 and 4 will have emissions more than doubling those of Units 1 and 2. These added emissions will increase the area of acidic precipitation and the resultant early detection type damage. Since the total SO_2, NO_X, and HF emissions from all four units would be greater than all other sources within a 200-mile area of Colstrip, it must be predicted that an ever increasing acidity of precipitation will occur throughout this area and that the major increase will occur in a 40 to 60 mile radius from the generating plants. Because of ponderosa pine's known sensitivity to acidic rains over that of other plant species growing in the Colstrip area, it will be the indicator to watch for the impact of this increasing acidic rainfall.

11.1.5.3. Vegetation Damage Caused by Phytotoxic Gases

In 1973, the U.S. Environmental Protection Agency (EPA) published a document entitled "Effects of Sulfur Oxides in the Atmosphere on Vegetation" which was a revised Chapter 5 for the Air Quality Criteria for Sulfur Oxides document. The importance of this publication must be stressed since the scientific information presented is the basis for setting and defending federal SO_2 ambient air standards. The most revealing aspects in this publication are the following:

1) There are 141 literature citations for Chapter 5 none of which deal with SO_2 or other air pollution problems encountered around coal-fired generating plants.

2) Of the 141 citations, the majority deal with the effects of SO_2 on coniferous species more than on any other species of plants.

3) No citations are from U.S. government plant scientists studying the effects of air pollutants on vegetation in and around coal-fired power plants of the TVA.

4) No citations refer to the numerous abatement activities and publications begun by the U.S. Department of Health, Education and Welfare (HEW) in 1965 and ending in 1972. The importance of abatement publications is that they demonstrate conclusively that in areas where severe air pollution problems occurred from SO_2 and other phytotoxic gases, the federal SO_2 ambient air standards were seldom to never violated. No other phytotoxic gas has received more study than SO_2. By far the largest portion of the United States literature on this subject deals with fumigation studies where known quantities of SO_2 are released for given periods of time into fumigation chambers filled with certain species of vegetation. Scientific papers on SO_2 and vegetation damage coming from Europe and Asia deal primarily with damage to indigenous plants and agricultural crops around large stationary sources. Unfortunately, while these articles adequately cover plant damage caused by SO_2 and other gases, they do not include ambient air levels of SO_2 or other gases except at one or two locations, at best, in large areas of damaged vegetation. This is primarily due to the cost of purchasing and operating elaborate monitoring equipment continually. This same problem of adequate ambient air monitoring has been encountered by the group of Canadian scientists headed by Dr. S. Linzon in their excellent studies on SO_2 damage to coniferous forests of Sudbury, Ontario, Canada, where large smelters have caused widespread devastation to the vegetation for many years.

The conclusions reached are that:

1) The best available literature on SO_2 damage has not been used--for instance, the expensive abatement studies by HEW where both ambient air monitoring and vegetation damage studies were conducted.

2) Fumigation studies on the effects of SO_2 on plant species are unrealistic since only one or two gases are used at a time and at given concentrations, therefore with no peaking concen-

tration or low periods.

3) None of the TVA data has been made available in the SO_2 criteria document even though TVA scientists are known to have been studying the effects of coal-fired power plants since 1950, 23 years prior to EPA issuing its revised SO_2 criteria chapter.

4) The voluminous scientific literature on SO_2 and the damage it causes to plant life is not covered even minimally by the 141 citations in the EPA sulfur criteria document.

Investigators who discuss or have studied the issue of plant susceptibility agree that coniferous species are one of the most susceptible species to emissions of large stationary sources such as coal-fired generating plants and non-ferrous smelters.

Abstracts of over 250 scientific articles dealing with SO_2 effects or a combination of SO_2 and other phytotoxic gas effects on vegetation are presently on file with the Energy Planning Division. These files are open to public review.

A. Tennessee Valley Authority

The TVA has operated coal-fired generating plants for over 24 years. During this time large sums of money have been spent to carry out baseline data investigations of vegetation prior to the building of the power plants as well as scientific evaluation of vegetation damage after the power plants went on-line. To date only one scientific paper has been released to the public concerning these studies. None of the baseline data has been made available.

The paper which was released covers the subject of white pine tree damage in east Tennessee. It was verbally presented at a meeting in Germany and then published in a German journal (Ellertsen et al. 1972).

According to the paper, the causal agent of damage to white pines in east Tennessee (Morgan County), even though admitted to be airborne and abiotic in nature, "cannot be determined" at this time even though the sulfur content of the pine foliage is twice the normal concentration and the sulfation levels for a four-year period at 25 permanent sampling plots averaged 0.099 mg. SO_2 per 100 cm^2 per day (Ellertsen et al. 1972). This concentration of SO_2, it should be noted, is $2\frac{1}{2}$ times less than Montana's maximum annual average for SO_2 and 5 times less than Montana's maximum one-month average. This doesn't mean that one can or cannot implicate SO_2 or its derivatives at the "unknown abiotic airborne" causal agent of the white pine damage. However, in an unpublished report written by Dr. H. C. Jones (1971), a plant pathologist and long-time employee of the TVA air pollution effects section, there is strong evidence of what this abiotic airborne causal agent might be.

Jones investigated preoperational precipitation chemistry in the area of Cumberland, Tennessee, 45 miles northeast of Morgan County where white pines were mysteriously dying. He found that for ten months (October 1971 through July 1972) the average pH value of rain collections was 4.5 and that the calculated pH value (by titration) was 3.9. However, a control rain sampling station, 35 miles from Cumberland, had an average pH value of 4.5 and a calculated pH of 3.9, which means that there was no area unaffected by SO_2 in the vicinities in which Jones was studying (Jones 1972, p. 13).

It should not be inferred that the data from TVA studies could be utilized for determining the impact of Colstrip Units 1 through 4 on the ecosystems of the Fort Union Basin, but it does aid in determining the rate of build-up of elements in the biological systems impacted by the emission of coal-fired power plants. It is extremely difficult, if not impossible, to equate with eastern Montana the biological impact of ambient air levels of phytotoxic emissions in the areas of the southeastern United States where TVA coal-fired power plants are operating. These areas have an annual rainfall of approximately 50 inches; the diversity and productivity of vegetation is much greater than in the Fort Union Basin. For example, coniferous trees utilized for lumber in the southeast have a 25 to 35 year rotation cycle while in the Fort Union Basin it is 100 to 150 years (from seedling to market).

Some investigators may argue that because of the faster growth, more rainfall and greater diversity in the southeastern states, damage from emissions of coal-fired generating plants or other large stationary sources should be greater than in a less diversified and drier area such as the Fort Union Basin. This is not so according to scientists who have worked in both types of ecosystems. In fact, this points to what will be brought out in the following discussion of data which have been accumulated while studying the effects of various phytotoxic air emissions of vegetation in different localities of the United States.

B. Mt. Storm Area of West Virginia, Maryland and Pennsylvania

The Mt. Storm study area is very similar to the Tennessee area of TVA studies. The Mt. Storm study is important to this report, however, because it is the only published literature (EPA 1971) dealing with coal-fired power plants and their emissions which also includes biological effects.

The important facts which come from the Mt. Storm study are:

1) Widespread damage was occurring to pine and spruce species being grown throughout the study area as well as far beyond study area boundaries which were 25 x 40 miles.

2) Similar visibly detectable damage was not occurring to species of fir trees nor to the abundant angiosperm species growing in the same area where the pine species were being affected.

3) Only once in over 7,000 hours of one hour readings (monitoring) did the SO_2 ambient air levels exceed the national three-hour standard; the average one-hour readings for the 7,000 hours were at or less than 0.01 ppm. Furthermore, the three monitoring stations were located at Christmas tree farms which were damaged by emissions from the power plants during the operation of the monitoring systems.

4) The pH value of rain water averaged 4.78 with a low of 3.50 during the spring of 1972 at 11 sampling sites.

After 4½ years of study, the acidity and chemistry of rain water from this area was proven to be the causal agent of the majority of the disease symptoms and syndromes being manifested by the pine species grown in the area. These symptoms were random needle dwarfing, premature needle casting, reduction in annual growth, reduction of lateral budding on some species of pine, and an acceleration of budding on other pine species. There are similarities between these pine tree symptoms and the previously mentioned TVA publication on damaged white pine trees of east Tennessee.

The major lesson to be learned from all of the scientific data derived from the Mt. Storm study is that federal ambient air standards which have been set for SO_2, NO_χ, and O_3 were rarely if ever exceeded, and thus one can conclude that in the Mt. Storm area the current standards do not protect many species of plants.

C. East Helena, Montana

The East Helena area, while a poor example for demonstrating what can be expected in the Colstrip area when and if Units 1 through 4 go on-line, does have similar annual rainfall (12" vs. 13") at approximately the same times of year and also has many similar plant species as the Fort Union Basin. However, the vegetation left in the East Helena area and currently being impacted (fumigated) by American Smelting and Refining Company (ASARCO) emissions has had 86 years to select for the emissions-resistant species and varieties or to adapt to these emissions.

There is information from East Helena, however, which helps evaluate the impact of power plant emissions in the Colstrip area. The first information comes from precipitation chemistry studies carried out for HES in 1973 and 1974 (Gordon unpub). The information thus far accumulated shows that the average pH value of all 78 total rain water samples was 6.67, with the lowest and highest pH values on any given collection being 4.78 and 8.80, respectively. The average pH value is well within the normal range of what is considered normal rain water. However, histological studies of necrotic needle bases from ponderosa pine collections made during the spring of 1974 from the top of MacDonald pass to Townsend at the southeast end of Canyon Ferry disclosed that acid burn was the cause of the necrosis. This type of acid rain damage was prevalent throughout the area and all pine foliage collection made in the entire Helena valley area showed this late detection symptom and premature needle casting. This means that in a 30-mile radius around the ASARCO smelter, acid rain damage was detected. The area of acid rain damage could be much further but an expanded area of investigation is needed.

The second relevant information from the East Helena studies is what happened in the area concerning vegetation damage by SO_2 fumigation in 1968 after ASARCO doubled their production in 1967. Even though the vegetation in a large radius around the ASARCO smelter had adapted to the previous SO_2 emissions, the increased emissions in late 1967 and during the 1968 growing season caused widespread SO_2 fumigation to occur in horticultural, agricultural, and indigenous plant species from the area. This SO_2 damage could be found on conifer trees throughout the valley and within the city of Helena. The phenomenon which is relevant to the Colstrip area is that of initial shock and damage to vegetation which is fumigated with a phytotoxic gas above previous levels.

Another example of the same initial shock phenomenon to previously pristine or clean areas, is the vegetation damage caused by the Rocky Mountain Phosphate plant emissions in the Garrison area almost immediately after the plant went on-line, and the vegetation damage which occurred in Columbia Falls after the Anaconda Aluminum plant expanded to three pot lines. Also, the history of the Anaconda Copper Company's Washoe smelter emissions, well documented in a Ph.D. thesis by MacMillan (1972), describes the initial 15 years of serious vegetation damage in an 18-mile radius around the smelter. The vegetation which remains in the radius around the Washoe smelter located near Anaconda manifests primarily chronic or late detection type SO_2 and acid rain damage and not the acute SO_2 damage which was present when the smelter went on-line.

D. Billings, Montana

A limited study on the air pollution problems to vegetation in Billings (Gordon 1970) provided a substantial amount of chemical analyses for sulfur and/or fluoride in vegetation and rodents. These vegetation and animal samples were collected one to six miles from the Billings Corette coal-fired generating plant and the nearby oil refineries as well as around the oil refinery at Laurel. Also, ponderosa pine and white pine which possessed both early detection symptoms (dwarfed needles with acid burnt basal tissues) and late detection (normal-length green needles with acid burnt basal tissues) were collected in the area of the Corette generating plant for histological studies. Histological examination of pine needles having tip burn was also completed from collections made along the Darby Rimrock area above the Corette plant.

The chemical and histological studies disclosed that both sulfur and fluoride air pollution damage to coniferous trees was prevalent as far as six miles away from the Corette plant and oil refineries located in Billings. Since no collections were made at further distances from the Corette plant, it is not known how far from this site the air pollution damage to pines extended. However, the concentration of sulfur in vegetation was such that it is obvious the survey and collection should have been extended two or three times the six-mile distance. The Billings study is important in relationship to the Colstrip area because:

1) There is good evidence at this time which indicates the emissions from the combined air pollution sources in the Billings and Laurel area are almost identical in SO_2 and NO_2 concentrations to what will be emitted by Colstrip Units 1 and 2. When Units 1 and 2 go online, the fluoride emissions at Colstrip will be 47% of the Corette plant in 1970. If one utilizes data presented in the State Implementation Plan for Control of Air Pollution in Montana, one sees that the total SO_2 emissions of the combined areas of Laurel and Billings are 25,638 tons per year which is only $1\frac{1}{4}$ tons per year more than the anticipated emissions from Colstrip Units 1 and 2 (see Westinghouse 1973 Table 2.3-9).

2) The SO_2 ambient air state standard was violated only twice during a six-month continuous monitoring period in 1973-74.

3) The average SO_2 ambient air levels during this six-month period of time ranged from 0.002 to 0.013 ppm which is 2½ to 5 times less than the federal three-hour standard.

4) The total NO_2 emissions in the Billings and Laurel area are fairly similar to the suggested NO_2 emissions coming from Colstrip Units 1 and 2 (i.e., 20,700 tons at Colstrip compared to 16,699 at Billings) (HES Implementation Plan 1971).

5) The fluoride emissions from Colstrip Units 1 and 2, due to the burning of coal containing an average of 33 ppm, is 31.18 pounds per day of 5.69 tons per year. This is assuming the scrubbers remove 95% of the 113.8 tons of fluoride per year which will be released by the burning of the 3,449,075 tons of coal per year in Units 1 and 2. If this 31.8 pounds per day or 5.69 tons per year of fluoride emissions at Colstrip is compared to the calculated 75.80 pounds of fluroide released per day at the Corette plant in 1970 (Glenn 1974) as well as the other two smaller coal-burning sources (HES Implementation Plan, Appendix E 1971, p.86), approximately half as much fluoride will be emitted by Units 1 and 2 as was emitted by the Corette plant in 1970 when the study was conducted. It should be noted that our studies at Laurel indicate the oil refineries add substantial amounts of fluoride to the atmosphere—the amount is not known.

If one considers the fluoride emissions which will be emitted if all four generating plants go on-line at Colstrip, then even assuming 95% collection efficiency there will be 17.9 tons of fluoride released per year or 98.2 pounds per day which will impact the ecosystems of the Colstrip area.

If one utilizes just the data which is present in the Westinghouse stack emission table (Westinghouse 1973, Table 2.3-9) for Units 1 and 2 to compare with the Billings and Laurel emission inventory of 1970, one can make some fairly accurate comparisons on what could eventually be the impact of Units 1 and 2 by themselves and then Units 1 through 4 if all go on-line. There are several points previously not mentioned of which the reader should remain cognizant:

1) According to the stack gas and particulate data obtained by personnel for the Department of the Interior at the Four Corners power plant (1972), mercury and fluoride were the only two elements which showed an increase in the stack flyash deposited by winds around the emission source over that which was already in the stack flyash (USDI 1972, p.13). Data from this report show that fluoride in stack particulate was 140 ppm and in wind-deposited flyash was 280 ppm. The increase of mercury content in particulate was also 100% being .06 ppm in the stack gases but 0.12 ppm in the wind-deposited flyash.

2) Within one mile of the Corette plant, the 15 and 27-month-old ponderosa pine foliage which was collected in August 1970, had average sulfur content twice as high as that found in the same-age ponderosa foliage from the 35 Colstrip

sites and was similar to that obtained in the damaged white pine in eastern Tennessee.

3) One to six miles from the Corette plant, the 15 and 27-month-old ponderosa pine foliage (1969 and 1968 foliage, respectively) contained an average sulfur content which was 50% to 60% higher than found in the same-age foliage from the Colstrip study sites.

4) The 15 and 27-month-old ponderosa pine foliage within one mile of the Corette plant contained 18.3 and 22.3 times more fluoride, respectively, than similar-age foliage from the Colstrip area.

5) One to six miles from the Corette plant, the 15 and 27-month-old ponderosa foliage contained four to ten times more fluoride than the same-age Colstrip area foliage.

6) Average fluoride levels in grass forage within one mile of the Corette power plant were 11 times that found in grass forage from Colstrip collection sites.

7) Average fluoride levels in Billings forage collected one to six miles from the Corette plant were 3.0 to 8.5 times higher than Colstrip area forage.

8) Average fluoride levels found in 26 deer mice collected within a six-mile radius of the Corette plant were 3.9 times higher than found in 12 deer mice collected from the Colstrip study area.

One subject not mentioned previously in this report is the concept of a yearly load of waste products on an ecosystem. The reason for not covering the subject earlier is that the majority of air pollution investigators have rarely utilized this concept in air pollution study areas and where it has been used only small portions of the needed information have been acquired. However, the information which has been obtained in Montana is exceptionally good in that it points out many of the "invisible" aspects of ecosystem disruptions caused by the impact of airborne pollutants. There are two areas in Montana where investigators, primarily graduate students using the studies for their thesis topics, have worked on the concept of annual waste load effects upon ecosystems. These areas are Anaconda and Hall, Montana. In Anaconda, Munshower studied the presence and movement of heavy metals through the soils and plants of that ecosystem (1972). Laird Hartman, a graduate student at the University of Montana Botany Department, is just finalizing three years of study on the presence and absence of microflora in the soils of the Anaconda area. His studies also include the tolerance limits of selected species of microflora to various heavy metals as well as their adaptability to various levels of those toxic metals in time.

Munshower's and Hartman's studies demonstrate vividly that in order to understand the impact of air pollutants on soil ecosystems in seriously polluted areas, one must consider the yearly load of airborne waste products upon that soil, and not how much SO_2, SO_4, fluoride, arsenic, etc. was in the cubic meter of air for any given hour of any given day from 1900 to the present. Even if waste products of airborne emissions are not present in the ambient air at a given time, but are present in or on the soil or on the surface of vegetation, many of these waste products, if not most, become entangled in those ecosystems and continue to cycle in and react with the physical and biological components.

This point is demonstrated by an air pollution study carried out in Hall, Montana (Gordon 1968-70, 1974a). At the top of the Douglas Creek drainage three miles southeast of Hall, Montana, a phosphate rock concentrating plant (Cominco American) operated from 1963 to October 30, 1968. The only air emission which came from the phosphate plant was particulate matter composed of fluoroapatite. This compound is highly insoluble in water and is actually pulverized phosphate rock. One could assume that as this "inert" airborne rock dust impacted the ecosystem of Douglas Creek and the surrounding drainages in the area, it would have little effect upon the biological components.

Three years (1967) after the phosphate plant went on-line, the cattle and sheep ranchers in the area noticed that many of their animals were becoming crippled and the young animals had mottled teeth. In 1968 studies were begun in the area on the fluoride content of the vegetation and in the bone tissues of indigenous animals (Gordon 1968). The studies revealed that none of the vegetation in the area was visibly being damaged by fluoroapatite even though up to 3000 ppm of fluoride could be retained on the leaf surfaces. The indigenous animals within a six-mile radius of the plant had elevated and excessive concentrations in their bone tissues. In October of 1968, this plant closed and it appeared that the problem would "go away" in a couple of years.

In 1973, a study of fluoride cycling in the aquatic vegetation, insects and fish of the Douglas Creek drainage was carried out (Gordon et al. 1974a). Findings disclosed that this "inert compound" was present at excessively elevated levels in the aquatic vegetation, insects and fish of the drainage.

In other words, fluoride is in the food chain and it is obviously going to stay there for some time. The reasons for this new prediction are many, but primarily it is based upon the fact that earlier attention was focused on the annual impact load and not the fluoride concentration levels in the dominant vegetation in the area (grasses and conifers). Calculations show that the fluroide which was released annually from 1963 to October 1968, was 2,500 tons per year and that this fluoride was and/or is tied up in the 84,000 tons of fluoroapatite particulate which was calculated to have been emitted from this prosphate operation each year. Therefore, what the biological systems of the Douglas Creek drainage and surrounding area (113 square miles of excessive fluoride levels) have to contend with in the future is that portion of the 12,500 tons of fluoride which was released between 1963 and October 1968, and is not yet removed by runoff waters from the drainages.

It is imperative that the total annual airborne emissions released from a stationary source be considered if one is to predict the longterm environmental impacts of those emissions. It is not improbable that excessive amounts of potentially toxic substance introduced into an ecosystem over long periods of time have far greater and more long lasting effects on that ecosystem than would concentrations of SO_2, O_3, NO_2 and HF in the ambient air which exceed the state or federal standards five or ten times a year.

In the Colstrip area the annual load of the emissions of the four coal-fired generating units must be taken into consideration when predicting the environmental impact of those units.

E. Impacts of Phytotoxins on Reclamation Species

Adequate reclamation has yet to be proven in Montana. The Montana Agricultural Experiment Station has been carrying out experiments for several years on test plots at the Rosebud Mine. To date these studies (Sindelar et al. 1973; Sindelar et al. 1974 unpublished) have demonstrated that with careful horticultural practices and management, certain species of introduced and indigenous plants can be established on some of the reclaimed strip mined areas. However, conclusive evidence that self-sustaining, permanent; diverse vegetative cover of predominantly native species is feasible in the semi-arid environment at Colstrip is lacking. Colstrip reclamation will be under increasing stress conditions with Unit 1 going on-line in July, 1975, and Unit 2 going on-line in 1976. These units will emit pollutants which are known to be toxic to all species of plants at varying levels of concentration. The additional stress of air-borne pollutants such as sulfur oxides and fluorides could destroy revegetation efforts.

There are currently 30 species of plants which are being utilized by WECO for reclamation purposes at Colstrip. Of these species (see Volume 3a, Section 9, Table 9-4), seven are cultivated or introduced to the area (i.e. fairway crested wheatgrass, tall wheatgrass, Lincoln bromegrass, orchardgrass, alfalfa, sainfoin, and yellow sweetclover) and the remaining 23, indigenous to the Fort Union Basin.

Four of these 30 species (Lincoln bromegrass, orchardgrass, alfalfa and yellow sweetclover) are listed by the EPA (U.S. EPA 1973a) as SO_2 - sensitive or susceptible and four others (woods rose, ponderosa pine, snowberry, and cottonwood) are listed as having intermediate SO_2 susceptibility. Limited or no data are available on the SO_2 susceptibility of the other 22 species, and limited data on the synergistic effects of SO_2, NO_2, HF, and O_3 are available on only one of the 30 species (ponderosa pine).

It is important to note that research is done more frequently on introduced or domestic species than on native species because of the availability and accessability of seed. Therefore, the fact that native species are not listed as susceptibile may mean only that research has not yet been done.

The four species listed above as being most susceptible to SO_2 fumigation damage, according to the published literature have been introduced into the Fort Union Basin. They are being planted primarily for 1) ground cover to establish organic matter in the soils, 2) protecting the indigeous species which establish themselves more slowly, and 3) reducing the amount of soil erosion. If Units 1 through 4 go on-line, emitting 60,000 to 91,000 tons of SO_2 annually into the atmosphere of the Colstrip area, these four species (and possibly others of the 30 species being utilized) will probably be damaged. The reclamation benefits of these species as sources of good ground cover and as nutrient sources after decomposition would be reduced due to the phytotoxic gases.

With SO_2, NO_2, HF, and O_3 fumigation occurring at the reclamation sites if Units 1 through 4 are built, the four semi-sensitive plants (ponderosa pine, cottonwood, wood rose, and snowberry) will also probably be damaged.

It therefore may be assumed from the data available on SO_2 sensitivity that at least eight of the 30 plants being used would be damaged to some degree by the emissions of Colstrip Units 1 through 4. In fact, after Units 1 and 2 go online, there is a strong possibility of damage to these eight species because of the synergistic effects of SO_2, NO_3, O_3, and HF.

When evaluating possible damage to reclamation species by atmospheric fumigation there is more to be taken into account than the information given by the EPA fumigation and sensitivity charts which were generally formulated under controlled, non-stress conditions. Physical and metabolic parameters of plants growing in SO_2 polluted atmospheres and possible synergistic effects must also be considered.

Nutrients affect susceptibility of plants to SO_2 Setterstrom (1938) demonstrated quite conclusively that alfalfa plants which have low availability of nutrients after fumigation with SO_2 show a reduced yield of biomass and are more susceptible to SO_2 damage than plants with adequate nutrient availability. Guderian (1971) also showed that seven species of plants grown in soil types with low nutrient availability manifested more severe SO_2 damage than if grown in soils with adequate nutrient supplies.

To date no one has studied or tested the 23 indigeous plant species being used for Colstrip reclamation purposes to ascertain if nutrient availability to these species is related to their SO_2 susceptibility or resistance to damage. However, evidence strongly suggests that they would react similarly to those plant species utilized by Guderian and Setterstrom. Therefore, it seems doubtful that at least some of these 23 species (which have unknown SO_2, HF, NO_2, or O_3 susceptibility ratings) would escape being moderately to severely damaged by the emissions from Units 1 through 4 if adequate nutrients are not available.

Under Montana's reclamation law, fertilization is allowed only for establishment of vegetation since the vegetation must be self-sustaining for the area to be considered reclaimed. Need and time for fertilization is decided on a case by case basis as topsoil conditions dictate. Often, however, fertilization of the reclaimed soils, if needed, would not be done until the year following the initial seeding period because of the possible adverse effects of the fertilizer on the young plant tissues during the seed germination and early growth period.

With first year fertilization, the reclamation species could be placed in jeopardy as almost all plants are more susceptible to phytotoxic gases during their early ontogeny when stomatal activity commences and during the early summer period of growth. This, coupled with inadequate or low nutrient availability during the early establishment period could cause a double stress on the plants.

It is possible that the combination of fumigation by phytotoxic gases during early ontogeny plus low nutrient supply could have more than a doubling effect. Dr. Park Nobel (1974) believes that plants which are under stress (i.e. water stress, low nutrient availability and so forth) when fumigated with phytotoxic gases (another stress) manifest more damage than the mere sum of the damage caused by each stress agent.

SO_2 and particulate matter also influence stomatal activity. When species of plants were tested for stomatal activity during periods of simulated SO_2 fumigation,there were indications that the stomata open earlier, open wider, and remain open longer when SO_2 is present at acute to chronic fumigation levels than when SO_2 is absent (Majernik et al. 1970, 1972). According to Majernik (1970):

> There are several possible unfavorable consequences of these effects. First, stimulation of stomatal opening by SO_2 is likely to increase considerably the access of the gas to the mesophyll and so damage caused will be greater. Second, for plants growing with a limited water supply, increased transpiration resulting from abnormal stomatal opening might lead to damaging or even lethal water stress.

Williams (1971) showed that particulate matter deposited on the leaves of deciduous trees caused stomata to remain open due to plugging, thus allowing the entrance of more SO_2 into the plant leaves and consequently more damage.

A large portion of the areas being reclaimed in the Colstrip area (WECO's Rosebud Mine and Peabody Coal Comapny's Big Sky Mine) will undoubtedly be fumigated continuously with extremely low but detectable levels (i.e., .01 ppm) to high levels (1.0 ppm) of SO_2 and NO_2. Because the stomata of some if not all of the plant species will respond to these elevated levels (above baseline 0.00 ppm) greater transpiration and gas exchange to these plants will occur not only during high humidity periods but during periods of low humidity. These above normal levels of gas exchange and transpiration will probably cause an increase of sulfur and fluoride accumulation and excessive loss of water in the reclamation plant species. It should also be noted that the highest annual concentrations of pollutants will occur within an approximate five mile radius of the plant site. This area includes much of the Rosebud and Big Sky Mine reclamation.

Since reclamation species are already being subjected to potential stresses of low nutrient availability, lack of a normal population of soil microflora and fauna, and a soil medium with undeveloped soil horizons, there probably will be more plant damage from phytotoxic gases at the reclamation sites in the Colstrip area than in the undisturbed areas.

Gaseous and particulate emissions may further cause loss of a significant portion of biomass and seed production. Bohne (1970) demonstrated conclusively the loss of plant growth from a combination of fluoride and sulfur accumulation in several species of agricultural and horticultural plants. He also found a 66% loss in the weight of seeds of winter wheat growing in close proximity to a pollution source emitting both SO_2 and HF gases compared to winter wheat growing further from the source.

Tingey et al. (1971 1974) working with interaction of NO_2 and SO_2 as well as O_3 and SO_2, demonstrated an increase in damage to plant tissue, loss of photosynthesizing tissue and a drastic reduction in biomass over the control of non-fumigated plants.

Facteau's (1973) studies with cherry trees show that cherry pollen viability is substantially reduced by HF fumigation.

Since few or no studies similar to those mentioned above have been carried out on the indigeneous plant species utilized at the Colstrip reclamation sites, it is difficult to predict the biomass loss. However, there undoubtedly will be some.

The potential implications of the research results discussed above are intensified by several additional parameters. First, one of the highest concentrations of particulate matter in the Colstrip area will be within the mine boundaries. Soil, overburden and coal dust particulates from the mining activities will be added to the 3,609 tons of particulate matter (Westinghouse 1973) which will be released by Units 1 through 4. Further, the SO_2, NO_2 and HF concentrations in the ambient air at the reclamation sites would reach substantial proportions during inversion and inversion break-up periods.

The aforementioned research results and potential problems point toward difficulties in addition to those already inherent in reclaiming the semi-arid lands near Colstrip. It is therefore quite probable that successful reclamation may be impossible as defined by law.

The Montana Strip Mining and Reclamation Act states that if an area cannot be reclaimed in accordance with its provisions, a permit shall be denied. If the stack emissions from the power plants or any combination of factors prevent establishment of vegetation on the mined lands at WECO's Rosebud Mine, a permit to operate the mine could be denied.

11.1.5.4. Calculations and Predictions of Air Emission Impacts from Colstrip Units 1 through 4 on the Physical and Biological Systems of Colstrip and the Surrounding Fort Union Basin

As previously stated, the 1970 air emissions of selected waste products from all sources in the Billings and Laurel, Montana area (Gordon 1970) will be compared with those emissions predicted from Colstrip Units 1 through 4 (Westinghouse 1973) even though there are some short comings in doing so.

The most obvious shortcomings of the comparison are that: 1) the emissions released in Billings and Laurel are from very short stacks in comparison to the tall stacks at Colstrip and 2) Billings and Laurel are separated by approximately 14 to 16 miles. Both of these facts reduce the geographical extent of maximum emission impact on the environment of the Billings and Laurel areas in comparison to what should be expected in the Colstrip area.

The positive aspects of comparison are that the physical and biological features and composition of the Billings and Laurel area are fairly similar to those in the Colstrip area. Also, several years of air pollution monitoring in the Billings and Laurel area by Jim Glenn (Director of Yellowstone County Air Pollution Control Agency) as well as a short but revealing study of species of flora and fauna in 1970 (Gordon 1970), lend themselves extremely well to predictions at Colstrip. In Table 11-18 are the total emission waste products data, from the Montana Implementation Plan (HES 1971). The data on line one of I. of Table 11-18 concerning SO_2, NO_2, and particulate emissions are from Battelle and the Montana State Board of HES. The fluoride emission data are calculated extrapolations from the results of stack gas monitoring by personnel of the Montana Air Quality Bureau. It is calculated that the Corette plant releases approximately 10 tons of fluoride per year based on 54.5 lbs/day emissions, and it is assumed from the fluoride analysis of vegetation and animals collected in Billings and Laurel (Gordon 1970) and Jim Glenn's sodium formate analysis at Laurel that 10 tons of fluroide are released by the refineries in Laurel and Billings each year. These calculations may be somewhat high, but even if so, the emission impact of Colstrip Units 1 through 4 would still be higher.

On lines II thru IV of Table 11-18 are potential and/or possible impact loads of these air emission waste products if they were distributed equally over 25, 100, and 500 square mile areas. Obviously these emissions are not distributed equally nor do they all necessarily impact only a 100 or 500 square mile area. However, it is believed that all of these waste products will impact the land. Because of the low stacks in Billings and Laurel, there is good reason to believe that the emission impact loads of 1,025 tons of SO_2 or 513 tons of sulfur, 22.6 tons of N or 668 tons of NO_2, 149 tons of partiuclate, and 1,600 pounds of fluroides (line 2, Table 11-18) can and do impact one-square mile areas in this region. Unfortunately, the biological changes and damages which have occurred in these heavily impacted areas of Billings and Laurel have not been studied. What have been studied, however, are ambient air levels of these compounds, for one-hour to 24-hour periods. Unfortunately, the levels bear no relationship to and do not assess the waste product impact upon the thousands of organisms in the soil over one to many years of continuous impact.

From the short study in Billings and Laurel in 1970, enough data was obtained on excessive fluroide and sulfur accumulation in plants and/or animals to show that there is a serious air pollution problem in these two areas. For instance, if one compares sulfur and fluoride accumulation data obtained from coniferous trees in three other seriously polluted areas of the United States (i.e., Mt. Storm, West Virginia; Anaconda and East Helena, Montana) to that obtained in the Billings and Laurel area, the seriousness of the pollution problems becomes apparent. In Table 11-19 are the results of the fluoride and sulfur accumulation in coniferous vegetation from Mt. Storm, West Virginia; Anaconda, East Helena, Billings, and Laurel, Montana. Also included in Table 11-19 are the base-line levels of these two elements found in the coniferous foliage collected within an 80-mile radi-

TABLE 11-18

BILLINGS AND LAUREL, MONTANA - 1970 EMISSIONS INVENTORY

		SO_2 (tons/year)	NO_2 (tons/year)	PARTICULATE (tons/year)	FLUORIDE* (lbs./year)
I.	Emissions	25,638	16,999	3,735	40,000
II.	Emission load impact on 1 sq. mile in a 25 sq. mile area	1,025.52	667.96	149.4	1,600
III.	Emission load impact on 1 sq. mile in a 100 sq. mile area	256.38	166.99	37.35	400
IV.	Emission load impact on 1 sq. mile in a 500 sq. mile area	51.276	33.4	7.47	80

* Calculated on the assumption that ½ of the fluoride emissions in the Billings and Laurel area come from the burning of coal and ½ come from oil refineries.

Source: Montana Implementation Plan, 1971, Table VI, p. 86; Battelle; State Board of Health and Environmental Sciences.

TABLE 11-19

AREA	YEAR	AVERAGE SULFUR CONTENT (ppm)	AVERAGE FLUORIDE CONTENT (ppm)	SO_2 EMISSIONS LOAD/YEAR (tons)
I. Mount Storm (scotch pine within a 30-50-mile radius from sources)	1969	900	3.4	788,400
	1970	925	3.9	
	1971	931	5.0	
II. East Helena (ponderosa pine within a 30-mile radius from source)	1970	1372	2.8	120,450
	1971	1458	13.8	
	1972	1491	10.1	
	1973	1366	5.7	
III. Anaconda (mixed conifers within a 30-mile radius from source)	1970	1537	3.3	254,280
	1971	1480	2.3	
	1972	1408	2.5	
	1973	1280	1.9	
IV. Billings & Laurel (ponderosa pine within a 6-mile radius from the source)	1968	1346	39.0	25,638
	1969	1380	35.3	(1970)
	1970	1146	28.8	
V. Colstrip (ponderosa pine within an 80-mile radius from potential sources: baseline)	1970	795	2.1	29,661
	1971	799	1.9	(Units #1-#2)
	1972	816	1.8	91,980
	1973	795	1.6	(Units #1-#4)

us of Colstrip, Montana. The sulfur accumulation in the conifers collected within a six-mile radius of Laurel and Billings is fairly similar to that found in the samples of conifer foliage from within a 30-mile radius of the ASARCO smelter in East Helena and the Washoe smelter at Anaconda. As noted in Table 11-19, the sulfur accumulation in the Scotch pine from the Mt. Storm area is substantially less than that found in the ponderosa pines from the less SO_2 polluted areas of East Helena, Anaconda, and Billings. This is not because Scotch pine starts at lower baseline level since the baseline level of Scotch pine foliage is 800 ppm of sulfur (Gordon unpub). Also, Scotch pine can accumulate as much or more sulfur in their foliage as can ponderosa pine when both are fumigated at the same SO_2 levels (Gordon 1972a). It seems that the reason for low sulfur accumulation in the Mt. Storm area is that the trees have been so weakened and subsequently their metabolism so reduced that little or no gas exchange is occurring between the atmosphere and the leaves. This is somewhat verified by the fact that annual growth is extremely retarded in this susceptible species throughout the Mt. Storm area.

It is obvious from the sulfur emission load data shown in Table 11-19 that there is a great deal of variation between the four polluted areas being compared. Two of the areas (East Helena and Anaconda) have a long history of air pollution dating back prior to 1900. Between 1965 and 1969, the advent of new 1000 to 1500 megawatt steam-generating plants (burning 1.5 to 3.0% S coal) within an 80-mile radius of each other resulted in the introduction of 700,000 tons of the current 788,400 tons of SO_2 into the Mt. Storm area (Gordon 1974b).

It seems that the staggering extra load of 700,000 tons of SO_2 plus all the hundreds of thousands of tons of NO_x and particulate which occurred annually in this short period of time in the Mt. Storm area is what caused the very rapid physiological and morphological damage to the coniferous trees. While the annual emission load of SO_2 in the Billings and Laurel area is 30 times less than in the Mt. Storm area, if the impact is much less it is still obvious that the impact did occur and did cause damage in these two previously undamaged areas. The Corette plant went on-line in 1968 and thus by 1970 had increased the annual SO_2 emission load to the area by four times (Glenn 1974). Therefore, it is unrealistic to assume that the 29,661 tons of SO_2 plus all of the other air emission waste products to be emitted by Colstrip Units 1 and 2 will not cause serious environmental impact on the ecosystems of Colstrip.

In order to present the potential impact of the emissions of Colstrip Units 1 and 2 and then 1 through 4 two tables have been prepared which compare the Billings and Laurel area emissions with the potential emissions which might occur at Colstrip. There is no basis to suspect the abatement equipment efficiency described by Westinghouse (1973) is incorrect: however, Table 11-20 (lines 1 through 3) has been prepared for purposes of comparison to show what the annual emissions of Colstrip Units 1 and 2 would be if the abatement equipment performs at 20%, 40%, and 95% efficiency. Westinghouse data (1973) have been used in all emissions except fluoride. As can be observed from the calculations in Table 11-20 if the data presented by Westinghouse personnel were incorrect and the scrubber takes

TABLE 11-20

COMPARISON BETWEEN ANNUAL EMISSIONS OF COLSTRIP UNITS 1 and 2, AND BILLINGS

EMISSIONS IN TONS/YEAR FOR:	WATER VAPOR*	SO_2	NO_2*	PARTICULATE	TOTAL FLUORIDE**
Colstrip 1 & 2 only; 20% control	2,119,920	39,547	20,761	185,011	91.
Colstrip 1 & 2 only; 40% control	2,119,920	29,661	20,761	138,758	68.3
Colstrip 1 & 2 only; 95% control	2,119,920	2,471	20,761	11,563	5.7
Colstrip 1 & 2 only; control per Westinghouse EIS	2,119,920 2,119,920	29,661	20,761	1,156	3.72
Billings & Laurel Area	unknown	25,638	16,699	3,735	20.0

* no controls
** assume 33 ppm F^-

out only 20% of the total potential sulfur emissions, there would be 10,000 more tons of SO_2 emitted from Units 1 and 2 than were predicted and 14,000 tons more than was released in Billings and Laurel in 1970. The particulate matter emission load at 20% abatement efficiency rather than the 99 +% predicted by Westinghouse would cause an increase of 183,855 tons annually to the emission impact load. However, if the abatement efficiency would be 40%, then the increase load would be only 137,602 tons over that predicted by Westinghouse. It should be pointed out that 85% to 95% particulate matter collection efficiency is not uncommon in well-maintained coal-fired generating plants, and thus if 95% collection efficiency were obtained, the annual particulate emission load of Units 1 and 2 would only be 10,407 tons more than predicted by Westinghouse.

The fluoride collection efficiency of 96% predicted by Westinghouse seems to be superior to what is obtained anywhere else, including the Rocky Mountain Phosphate plant at Garrison. Therefore, if collection efficiency is 40% rather than 96%, there would be 64.6 more tons of fluoride released annually. Also the 68.3 tons released into the atmosphere at 40% collection efficiency is over three times the amount calculated in Billings (Gordon 1970).

Regardless of calculations at 20, 40, and 95% abatement efficiency, it seems from reading TVA data and materials as well as the arguments presented by utility company officials in the Maryland and West Virginia areas of the United States, that the emission data presented in the Westinghouse report makes Colstrip Units 1 and 2 one of the most, if not the most, efficient power plant complex thus far built.

Regardless of the first two Colstrip generating units' efficiency in emission abatement, additional units will obviously cause an increase in the annual waste product load to the atmosphere. Table 11-21 demonstrates these increases, with calculations utilizing the data from the Westinghouse report and the Billings and Laurel emission inventory summary (HES 1971) with the exception of the fluoride data. As can be observed on lines 1 and 2 of Table 11-21, the annual SO_2 emission at Colstrip, when and if all four units are operating, would be 66,342 tons more than is currently impacting the ecosystems of Billings and Laurel. The particulate matter loads of both areas would be similar and the annual fluoride emission at Colstrip would only be two tons greater than in the Billings-Laurel area.

The annual emission levels for Colstrip Units 3 and 4 only are shown in Table 11-22 for various control levels. It can be seen that the SO_2 emitted by Units 3 and 4 is slightly over two times that emitted by Units 1 and 2 at 40% scrubber efficiency. The fluoride levels emitted annually by Units 3 and 4 are nearly two times that emitted by Units 1 and 2 at 40% control.

Referring back to Table 11-19, note that the fluoride levels of the Billings and Laurel conifers are about three to four times higher than that found in East Helena conifers and 14 to 19 times higher than currently are present in Colstrip area conifers.

The added combined annual tonnage of NO_2 and

TABLE 11-21

COMPARISON OF COLSTRIP EMISSIONS FROM UNITS 1-4 WITH BILLINGS AREA EMISSIONS

			Tons/Year			
Assuming Equal Distribution On a Given Land Surface	Location	Water Vapor	SO_2	NO_2	Particulate	Total Fluoride Gas & Particulate
Stack Emmissions Running at Full Capacity	Colstrip	6,570,000	91,980	64,824	3,609	17.9 tons/yr. or 35,846 lbs/yr.
	Billings	-	25,638	16,699	3,735	40,000 lbs.
Emission Load Impact on 1 Sq. Mile in a 25 Sq. Mile Area Each Year	Colstrip	262,800	3,679	2,592	144	1,433 lbs/yr.
	Billings	-	1,025.5	667.9	149.4	1,600 lbs.
Emission Load Impact on 1 Sq. Mile in a 100 Sq. Mile Area Each Year	Colstrip	65,700	919	648.2	36	358 lbs/yr.
	Billings	-	256.4	166.9	37.4	400 lbs.
Emission Load Impact on 1 Sq. Mile in a 500 Sq. Mile Area Each Year	Colstrip	13,140	184	109.6	7.2	71 lbs/yr.
	Billings	-	51.3	33.4	7.5	80 lbs.

TABLE 11-22

Emissions from Colstrip Generating Units #3 and #4*

Emissions in tons/year for:	SO_2	Partic-ulate	Gaseous F^-	Partic-ulate F^-	*** Total F^-	** NO_2
Colstrip 3 & 4 only No control	104,518	490,560	54.8	131.4	186.2	44,062
Colstrip 3 & 4 only 20% control	83,614	392,448	43.8	105.1	149	44,062
Colstrip 3 & 4 only 40% control	62,710	294,336	32.9	78.8	111.7	44,062
Colstrip 3 & 4 only 95% control	5,226	24,528	2.7	6.6	9.3	44,062

*Coal ananlysis (Westinghouse 1973)

** No controls at the stack

*** Assume 33 ppm F^-

SO_2 emission wastes from Colstrip Units 1 through 4 which would impact the Colstrip area is over 100,000 tons greater than what is currently occurring in the Billings-Laurel area. However, the total air emission waste products at Colstrip when and if Units 1 through 4 go on-line should also be considered in terms of the predicted water vapor emissions at Colstrip (Westinghouse 1973). These vapor emissions will combine with the SO_2, NO_2, HF, and water soluble particulate to form compounds. It should be noted that there will be a substantial tonnage of waste products impacting the lands of the Fort Union Basin -- 6,730,430 tons per year (Westinghouse 1973, p 2-92). Therefore, Table 11-21 also presents the annual impact load of waste products on 25, 100, and 500 square mile areas and compares them with what potentially is impacting the same acreage in the Billings and Laurel area (HES 1971). As one can ascertain from Table 11-21, the increased impact load on 500 square miles in the Colstrip area is over three times greater than in the Billings and Laurel area where there is air pollution damage currently occurring.

If the daily and annual impact load of sulfur and fluoride compounds on an area could be determined from the data obtained by static or dynamic air pollution monitoring devices, the results would not be the same as the data presented in Table 11-21. The differences are shown in Table 11-23, utilizing the air emission data obtained at Billings and Laurel (Glenn 1974) and then extrapolating the data to demonstrate the amounts of waste products landing on a square mile according to static monitoring readings.

When the highest sulfur readings obtained at Laurel and Lochwood (Billings) were utilized, there were only 872 and 397 pounds of reactive per square mile, respectively, at those two sampling sites. This is substantially lower than even the 51 tons/square mile when the SO_2 is impacting a 500 square mile area (Table 11-21, Line 8). What is interesting is that the annual fluoride impact loads in both Laurel and Lochwood are very, very close to what is predicted in Table 11-21. However, if one utilizes the data in Table 11-21 and 11-23, this means that there are 500 square miles this fluoride load in the Billings-Laurel area. At this time there is no explanation of the large discrepancies between what one can calculate from waste product emissions impact load and data obtained and extrapolated from static sulfation samples.

A. Plant Damage

As previously mentioned (in section 10.1.6.), the 35 sampling sites which were selected as vegetation study plots are in almost all cases situated on elevated areas in relation to the surrounding lands. The vegetation at sites selected for chemical analysis of fluorides and/or sulfur content are species which will either accumulate one or both compounds at a faster rate or manifest visible injury earlier than the other plant species which were not utilized for study. The fastest accumulation and the highest concentrations of fluorides will occur in the Rocky Mountain juniper. However, no visible fluoride damage will occur to this plant until after all of the susceptible and resistant strains of ponderosa pine are dead. It should be noted that those species of plants which accumulate the highest concentrations of either

TABLE 11-23

Calculations on Annual Load from Jim Glenn's 1973-74 Data on Ambient Air Monitoring in Billings and Laurel

		SO_2 ugm/m^3/24 hrs	SO_2 ppm	Sulfation ugm/100 cm^2/ day	SO_4 lbs/day/sq mile	Reactive Sulfur lbs/year/sq mile
Laurel 1/2 mile from Farmers Co-Op Refinery	Ave.	40.0	.013	2.10	1.20	438.0
	High	281.0	.097	4.19	2.39	872.0
	Low	-	-	0.59	0.34	124.1
Lockwood 3/4 mile E.N.E. of Exxon Refinery and 2 miles N.E. of Corrette Generating Plant	Ave.	25.0	.007	0.81	0.46	167.9
	High	161.0	.057	1.91	1.09	397.0
	Low	-	-	0.11	0.06	21.9
Billings Downtown	Ave.	12.0	.004	.004	0.13	47.4
	High	-	-	-	-	-
	Low	-	-	-	-	-

TABLE 11-23 (cont.)

Calculations on Annual Load
from Jim Glenn's 1973-74 Data on Ambient Air Monitoring in Billings and Laurel

		F^- ugm/100 cm^2/28 days	F^- lbs/sq mile/28 days	F^- lbs/sq mile/year
Laurel 1/2 mile from Farmers Co-Op Refinery	Ave.	9.93	5.6	72.8
	High	23.70	13.5	175.5
	Low	1.63	0.93	12.0
Lockwood 3/4 mile E.N.E. of Exxon Refinery and 2 miles N.E. of Corrette Generating Plant	Ave.	3.67	2.09	27.1
	High	8.82	5.03	63.4
	Low	0.38	0.22	2.86
Billings Downtown	Ave.	0.51	0.29	3.77
	High	1.07	0.61	7.93
	Low	0.16	0.09	1.17

sulfur or fluorides present in the ambient air in a given sampling plot are almost without exception the most resistant species to these phytotoxic gases. The first plant species in the Fort Union Basin which will visibly be damaged by the phytotoxic emissions of Units 1 and 2 will be the ponderosa pine species. This damage will be manifested in the foliage of the trees by yellowing, necrosis, and premature needle casting. Those ponderosa pine which are in their seedling stage, such as the ones in the reclamation plots at Colstrip, will probably be the first to manifest these symptoms since during the seedling stage this tree species is extremely susceptible to both sulfur and fluoride emissions.

Seed production of the ponderosa pine as well as other species of plants will probably increase due to the stress caused by phytotoxic gases, but little to no increase of reproduction will occur. In fact, there should be a dramatic decline in pine seedling production in the Colstrip area as there is now around the Anaconda and East Helena smelters.

Because of the large water vapor emissions from the cooling towers at Colstrip, acid rain damage to the flora will occur at sites within the impact area of the water vapor. At further distances acid rain damage will occur throughout the Fort Union Basin sporadically during rain-out and wash-out episodes or following the interaction of normal rain with acids present as the result of dry deposition.

Because of the current presence of acid rain damage to ponderosa pine foliage, the added burden of SO_X, NO_X, and HF will cause an increase in the acidity of the rains that fall within a 600-mile radius of Colstrip. The rains containing the greatest concentration of acid should, however, occur within a 50-mile radius of Colstrip and there is a very likely possibility that these acidic rains will cause measurable damage to other species of flora in the area as well as some leaching of nutrients from the soils. Figure 11-20 demonstrates the major impact area of the acid rains.

With the advent of Colstrip Units 3 and 4 going on-line with a three-fold increase of emissions (Table 11-21), the plant damage in the Colstrip area should be similar to that which occurred in the Helena valley in 1967-1968 when ASARCO doubled their previous metal productions and thus raised their SO_2 emissions from approximately 70,000 tons to the current 120,000 tons per year. Typical SO_2 damage symptoms were observed on nearby barley and horticultural crops and indigneous plants as far away as six miles and greater. This prediction is based on Westinghouse (1973) estimates of pollution abatement equipment efficiency of Units 1 through 4. If these estimates are incorrect, however, the efficiency is 1/3 to 1/5 of what they have predicted, the plant damage in the Fort Union Basin area of Colstrip should be similar to what occurred in the Deerlodge valley when the Washoe smelter at Anaconda went on-line in the early 1900's. Sulfur dioxide damage symptoms were found on vegetation (mainly coniferous species) up to 15-20 miles away from the smelter.

VEGETATION SAMPLING SITES

MAJOR ACID RAIN IMPACT AREA

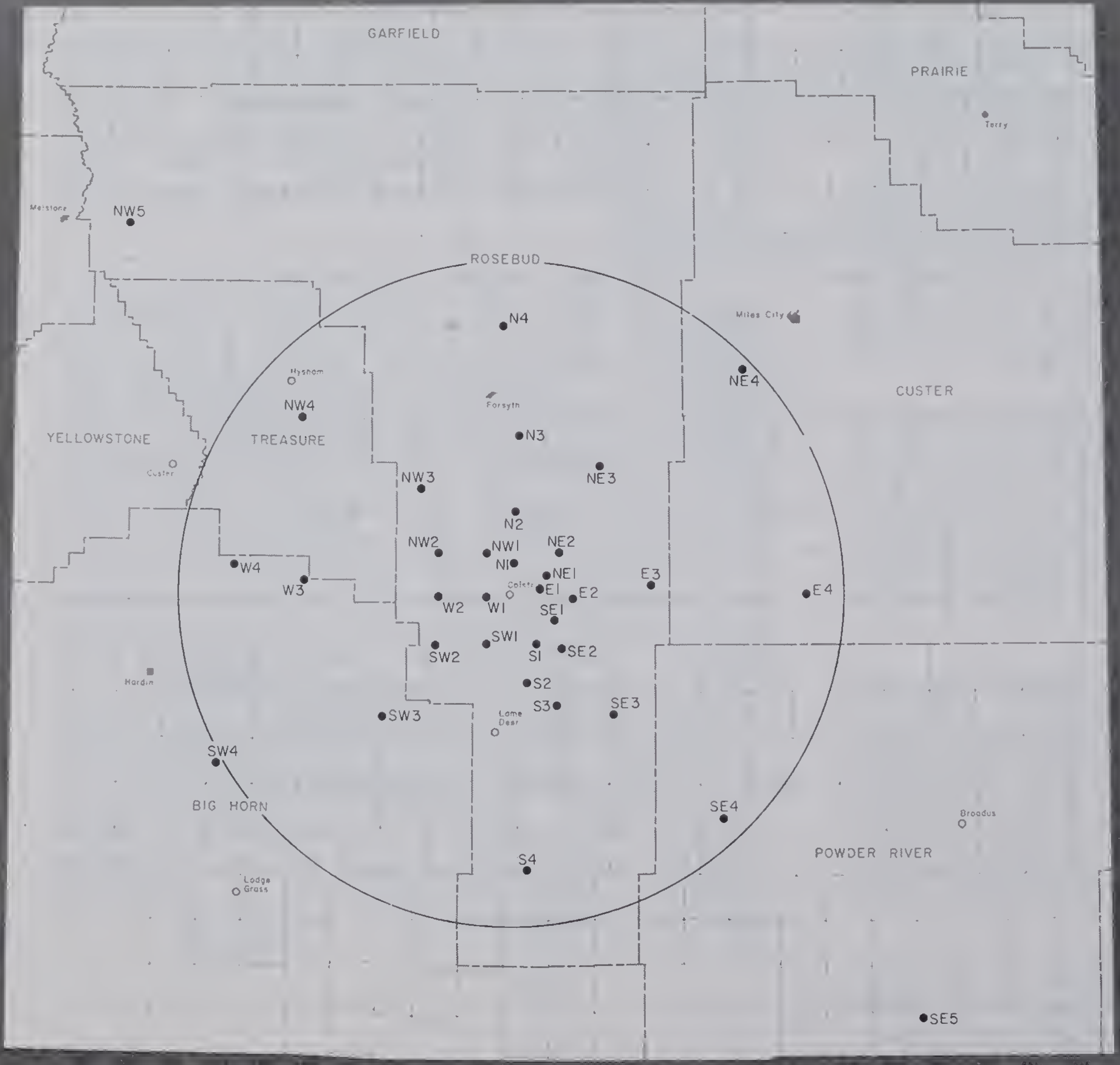


FIGURE II-20

11.1.5.5. Construction Impacts

The impact of the Units 3 and 4 pipeline on the environment would result mainly from construction and maintenance of the line after construction.

From the initial clearing and grubbing of the 60-foot right-of-way to the final clean-up phases, all vegetation within the right-of-way would be destroyed. Following construction, the land would be contoured to return it as close to its original appearance as possible. The eventual impact on the vegetation would depend on how the soil profile is replaced. If "C" horizon (parent material) is placed on top, it is not likely to support the same vegetation as would the "A" horizon (topsoil), or perhaps any vegetation at all. Especially important is the replacement of the soil layers of low permeability or possible toxicity. Such layers must be placed under desirable fill to avoid detrimental effects. Apart from the placement of soil horizons, slope, aspect, temperature, moisture, and animal activity also may vary the impact. The length of time to revegetate an area is dependent on the above factors. For example, north slopes are cooler and usually have more available moisture than south slopes and are likely to revegetate faster. Typical revegetation management of disturbed areas should restrict seeding to spring or fall seeding periods as areas are readied for surface treatment and perennial vegetation. There could be instances where sites would necessarily remain untreated for a time, such as when construction is finished in midsummer and precipitation is low. During such periods it is desirable to temporarily stabilize the areas with vegetation to limit wind and water erosion. Annual grasses function well for temporary stabilization Sindelar et al. 1973).Areas of low soil stability, such as sandy steep slopes, should be treated with special care or they could develop into blow-outs or be subject to extensive gullying.

It is immensely important that species be suitable to the areas on which they are to be planted. Equally important to consider is the purpose for which the species will be used, such as grazing, browse, or stabilization. In most instances, it is highly desirable to have a balance of shrubs, forbs, and grasses on a given site (Plummer 1970).

Plant succession on disturbed sites will be affected by the kind of plants adjacent to the site and the seed crop they are capable of producing. On exposed mineral soils, various pioneer plants will invade. For this part of Montana, these invaders will be annual fescues and bromes, and many other annual species including Canadian thistle, leafy spurge, Russian knapweed, and prickly pear (USDI 1973). Most invading species are highly competitive and do well on most sites. Care should be exercised to avoid invasion by these and the possibility of introducing new invading species.

The amount of available nutrients is essential to successful revegetation. The soils in this area are usually nitrogen and phosphorus deficient. However, application of fertilizer should be used with discretion. For example, an excess of phosphorus in what was originally a grass community, tends to favor broadleafed plants (Morris 1974b). Fertilitizer may also affect the symbiotic and non-symbiotic balance of soil fungi and bacteria (Buckman and Brady 1961).

Maintenance of the pipeline will create an access road the length of the line. If travel is restricted, the problem of disturbance will not be severe. Caution should be used on steeper slopes, especially those with low soil stability. Unless unavoidable, roads should not be used during wet or rainy periods to avoid rutting and other complications.

The impact of construction of Units 3 and 4 would not be great though construction of the power plant would require mining of coal as part of the construction process. The potential site for Units 3 and 4 is underlain by a seam of McKay coal. This coal would have to be removed in order to provide for a good foundation base for the power plant. The site for construction is presently a parking lot so a minimal amount of vegetation would be lost in construction. However, new parking access areas and utility buildings would take further areas out of production. Soil compaction resulting from use of heavy equipment, and the land taken out of production by the presence of the plants themselves, are the primary impacts of plant construction.

11.1.6. Impacts on Wildlife

Construction and operation of Colstrip Units 3 and 4 would result in a number of impacts upon wildlife. Construction of the power generating complex itself would result in the loss of about 700 acres of wildlife habitat, and the strip mining of areas C, D, and E (Volume 3a, Chapter 9, Figure 9-1) to provide coal for the complex would result in the destruction of an additional 12,000 acres of habitat over the projected 37-year life span of the plant. Further habitat loss, increased hunting pressure, and harassment of wildlife would result from the population increase in the study area, estimated to stabilize by 1985 with a total increase of 4,500 to 6,000 persons. The population increase which would be associated with construction of the plant complex is estimated at 5,800 to 10,000 by 1978. Gases and particulates emitted by the complex would affect both wildlife and domestic stock. Reduced flows of the Yellowstone River due to water withdrawals by the complex might result in negative impacts upon fish and birds using the river.

11.1.6.1. Impacts of Habitat Loss and Increased Population

Wildlife habitat losses resulting from plant construction and population increases would be permanent, while habitat lost due to strip mining might be replaced over a period of years or decades by reclamation and/or natural succession processes. Large mobile mammals such as antelope, mule deer, and whitetail deer, as well as most birds, would be displaced from these affected areas into adjacent areas; population levels in adjacent areas would eventually adjust downward to the original densities. The smaller mammals, such as prairie dogs, would be destroyed by construction and mining operations. Destruction of the five known sharptail grouse breeding grounds in mining areas C, D, and E would, at least temporarily, eliminate nesting activities and drastically reduce production. Loss of these and other wildlife species from strip mined land might in many cases last until natural succession restores vegetation types similar to those present before mining. It has not yet been determined whether these lands can be successfully reclaimed to a condition suitable for the support of indigenous wildlife species.

The projected population increase in Rosebud County would undoubtedly result in a large increase in both legal and illegal hunting. This increased hunting pressure would probably result in more restrictive hunting regulations for those game species (mule deer and antelope) whose harvest rates are now close to being adequate. Additionally, the large population increase may result in increased harassment of wildlife from recreational pursuits such as trail bike riding, snowmobiling, and four-wheel drive vehicle enthusiasts.

11.1.6.2. Impacts of Pollutants on Wildlife

A. Fluoride Emissions

1. General Effects of Fluorides on Animals

Fluorides are emitted from industrial sites in Montana as waste products of several types of operations. One operation involves the production of aluminum in an electrolysis process using cryolite ($3NaF\ AlF_3$) as the electrolyte. A second operation involves the production of domestic feed phosphates from rock phosphate containing varying levels of fluoride (usually 2-5%) (Van Wazer 1961). A third operation is the burning of fossil fuels. In all these operations soidum fluoride (NaF), which occurs as a particulate, and hydrogen fluoride (HF), a gas, are waste materials emitted into the atmosphere.

Fluorides dispersed from an industrial site into the atmosphere are carried to and collected by vegetation in relation to the topography and prevailing winds. Studies by Gordon (1967), Carlson and Dewey (1971), Kay (1974) and EPA (1974) present data on the geographic distribution of fluorides in and on vegetation in relation to an industrial source. These studies show a graded accumulation of fluorides in and on the vegetation of from 600 ppm near the source to 10 ppm at the edge of the affected area. Sodium fluoride adheres to the vegetation, and both forms of fluoride are absorbed through the leaf stomata of the plant. Once in the foliar tissue, both forms of fluoride are soluble and tend to accumulate at conifer needle tips or broad leaf margins (Carlson and Dewey 1971). Fluorides also accumulate in tissues of pollen, stems, and terminal buds by passing along the metabolic pathways of the plant (EPA 1974).

All experimental and field studies examined indicate that livestock and wildlife are primarily affected through the ingestion of contaminated vegetaion. Experimental studies of domestic stock show that excess fluoride is accumulated in the bone structure. Little if any is accumulated in soft tissues or fluids. This results in little hazard to human health, but causes varying degrees of disfiguration and structural bone damage to the animal.

2. Effects of Fluorides on Domestic Stock

Domestic stock can be exposed to fluoride from the air, from ingestion of forage or hay, from feed supplements, and from the water supply. The primary source of contamination is from forage or hay. In extreme cases, usually the result of gross oversight on the part of stock feeders, acute fluorine toxicosis can occur. The symptoms of this condition are excitement, high fluorine content of blood and urine, stiffness, reduced milk production, excessive salivation, vomiting, incontinence of urine and feces, clonic convulsions, necrosis of mucosa in the digestive tract, weakness, severe physiological depression, and cardiac failure.

The response most often observed in livestock and certain wildlife is chronic fluorine toxicosis (Shupe et al. 1972). This condition develops over a period of time and is influenced by several variables such as amount of fluoride ingested, duration of ingestion, fluctuation in fluoride intake with time, solubility of fluoride ingested, the nature of the species involved, age at time of ingestion, general level of nutrition, stress factors, and individual biological response. Of these variables, high levels of fluoride intake are most important, because 99% of the fluoride retained in the animal is stored in the skeletal structure (Shupe et al. 1974). Several experimental studies conducted on domestic stock found that symptoms of chronic fluorine toxicosis, including dental fluorosis, osteofluorosis, lameness, and stiffness, resulted from high levels of fluoride in the diet (Shupe 1972a and 1972b, Suttie 1969, Suttie and Faltin 1971, Shupe 1967, Johnson 1965, Allcroft et al. 1965, and Jones 1972). A second important variable is the fluctuation of fluoride intake with time. Allcroft et al. (1965) found monthly variations of 25-292 ppm fluoride (dry wt. basis) in pasture vegetation. Benedict (1970) found monthly variations of 12-117 ppm in the same type of vegetation. Nearly three-fourths of these monthly readings were well above the Montana standard for fluoride in vegetation (35 ppm dry wt. basis). Solubility is a third factor. The toxicity of fluoride increases as its solubility in water increases. In research conducted primarily on rats, the fluoride in sodium fluoride was most toxic, while that in rock phosphates was intermediate in toxicity. (Shupe et al. 1974). A fourth factor is the nature of the particular species involved. Cows, horses, and pigs display different tolerances for dietary fluoride. These tolerances vary from 30-100 ppm fluoride (dry wt. basis) for sodium fluorides (Shupe et al. 1974). Above these levels, pathological changes may occur, resulting in various symptoms of chronic fluorine toxicosis.

3. Effect of Fluoride on Wildlife

High fluoride accumulations in various mammals are directly correlated with the contaminated vegetation ingested. In wild animals examined for excessive fluoride levels in Glacier National Park, the ratio of the concentration of fluoride in the vegetation to the concentration in the animal was always greater in the Park than among controls, indicating long-term accumulation of fluorides in the animal. Control animals had 7-30 times less fluoride concentrated in their bones than animals in the Park. Accumulation of fluoride in increasingly higher concentrations within higher trophic levels was also found in a study by Dewey (1972) on predatory insects. In addition, vegetation in this area that was important to wildlife for food and cover was more susceptible to damage than other vegetation. Although this information indicates no direct adverse affects to the wild animal itself, it does indicate there is an effect on the habitat, and in time there may also be effects upon the animal in the form of chronic fluorine toxicosis due to fluoride accumulation.

In Carlson and Dewey's 1971 study, whitebark pine, a seral species, was most affected by fluorides of the four conifer species examined. This may cause a premature decline in the seral community, which is important to wildlife, and an acceleration of succession toward climax. Several of the shrub species in the seral community are important to wildlife for feed, for example, juneberry and chokecherry. It is important to note that among the shrub species examined, juneberry and chokecherry were most sensitive to fluorides.

These studies imply that the food chain response observed and the trend toward premature vegetative climax will, in time, cause a decrease in available wildlife habitat and produce varying symptoms of chronic fluorine toxicosis.

B. Other Emissions

Colstrip Units 3 and 4 would emit many trace elements which are toxic to animals. Mercury would be emitted at the rate of 0.242 lbs/hr, lead at 0.672 lbs/hr, and arsenic at 0.672 lbs/hr.

Mercury contamination of watersheds in the vicinity of the Four Corners generating plant in New Mexico has been documented (U.S. Dept. of Interior (1972a). Aquatic organisms concentrate mercury within their bodies when the intake rate exceeds the elimination rate (Glosschenko 1969). The resultant build up of mercury may become toxic and lethal. Human deaths which were the result of mercurial accumulations in fish caught for human consumption have been reported in Japan (Buhler 1973). Dead fish found in the vicinity of those which were caught and eaten had mercury concentrations ranging from 9 to 24 ppm. Because these fish died of mercury poisoning, it is assumed that freshly caught fish which caused human deaths probably contained less mercury (Lofroth 1969).

For aquatic organisms, mercury and its compounds are some of the most poisonous substances known (Buhler 1973). Methylmercury concentrations in fish in Navajo Lake, Colorado, near the Four Corners generating plants, are near the lower limit of the range of mercury concentrations noted in fish thought to cause human deaths in Japan, with 1.4 ppm for brown trout and 8.9 ppm in chubs (Hyder 1971).

Other impacts may result form acid rain and acid waters produced by SO_2 emissions, estimated to be 15,146 lbs/hr from Units 3 and 4. Sulfur dioxide, when released into the atmosphere, becomes slowly oxidized to form sulfur trioxide (SO_3). It is then converted to sulfuric acid by reaction with water, and returned to the ground during precipitation. The acidification of lakes and streams and its effect on aquatic organisms has recently been documented. A marked decline in the fish populations in the La Cloche mountain lakes in Ontario was reported as a result of increased acidification due to a copper smelting plant 45 miles away (Beamish and Harvey 1972). Schofield (1965) reported a significant lowering of pH values in lakes of the Adirondack Mountains of New York from 1938 to 1960. Such contamination of watersheds by stack emissions from the Colstrip generating complex may be detrimental to wildlife resources in southeastern Montana.

Because of the relatively low sulfur content of coal in Fort Union deposits, acid mine drainage is not expected to be a problem in this area.

C. Site-specific Impact Predictions

The measurable damage to animals by fluoride emissions from Colstrip Units 3 and 4 are difficult to predict. Colstrip Units 1 through 4 would release 23 tons/year of fluoride at an 80% load factor. Those species of animals utilizing the foliage of plant species which are fast accumulators of fluoride, such as Rocky Mountain juniper and bluebunch wheatgrass, will accumulate fluorides more rapidly than those that utilized seeds, berries, or foliage of plants which are not fast accumulators of fluoride. An exception to this prediction would be in the impact area of the particulate emissions of Units 3 and 4, which would contain rather substantial levels of fluoride. This particulate fluoride adheres to the seeds, berries, and foliage and thus is consumed by the animals which utilize these foods for their diet.

If Colstrip Units 3 and 4 go on-line, buildup of several toxic substances (mercury, lead, and boron) along with fluoride will occur in the indigenous species of animals. Physiological and/or bone tissue damage will occur to the indigenous species prior to the domestic animal population in the area. This damage will probably be first noticed in small mammals, then in grouse, and then in larger herbivores. Carnivores are expected to follow the trends of their primary prey.

There are indirect or secondary types of damage to plants and animal species which are difficult to measure since they occur rather slowly and insiduously. For instance, a reduction of pollinating insects such as honey bees could and probably would occur with the advent of increased fluoride levels in the ambient air and the environment. This in turn would reduce seed production in species of plants pollinated by these insects and thus reduce the food source in the future for the foliage and/or seed-eating animals of these plant species. Secondary causes such as these, which are difficult to predict, are believed to have been partially responsible for the reduction of animal and plant species diversity in such places as Sudbury, Ontario, and East Helena and Anaconda, Montana, as a result of atmospheric emissions from stationary sources located at those sites.

11.1.6.3. Potential Impacts from Dewatering of the Yellowstone River

The water requirements for Colstrip Units 1 through 4 represents the first major energy-related water demand on the Yellowstone River in northeastern Montana. The water withdrawals resulting from operation of Units 3 and 4 by themselves would not significantly reduce the flow or water level of the Yellowstone River. However, it would be realized that the individual impacts of present and future water withdrawals are cumulative, and that the impact of a given river depletion will be magnified with each successive use of Yellowstone River water. Therefore, in the following discussion, impacts resulting from reduced flows and water levels are discussed although these may not result directly from the operation of Units 3 and 4 alone.

A. Impacts on Migratory Birds Using The Yellowstone River System

1. Canada Geese

Reduced river flows during spring may have an effect on nesting geese. Reduced water levels in early spring may cause some islands to become contiguous with river banks, or may produce slow, shallow channels on one or more sides, decreasing the security of the island, and undoubtedly decreasing the attractiveness of these islands for nesting.

When geese have brought off their broods in a reduced water level situation, brood concentration areas (often large quiet backwaters) are limited in number and/or reduced in size. Security of the geese during the molt would suffer under these conditions.

Fall counts of geese on the lower Yellowstone River below Miles City are usually much lower than those near Rosebud and above. This may be related to the abundance of islands in the upstream sections. Geese in the Terry-Fallon area most often loaf on the river banks because of a scarcity of suitable loafing islands in this area. When geese loaf on islands contiguous with river banks or on the banks themselves, they are more vulnerable to hunters and other predators. Reduction of flows in the Yellowstone could reduce the number of open islands for loafing which are essential to geese in late summer and fall.

Reduced water levels in winter may have three noticeable effects on the geese along the Yellowstone River. First, reduced flows could cause the river to freeze over in certain sections earlier than under present flows, causing geese using these sections to migrate earlier. Second, reduction of flows during the spring ice break-up period can reduce the extent and vigor of island ice-gouging. This would allow advancement of plant succession on previously ice-gouged sites which would decrease the amount of vegetation-free loafing areas available for use by geese and produce heavier vegetational cover around nesting sites. Preferred nesting sites offer good visibility from at least one side of the nest (Childress 1971). Third, reduced flows would possibly prolong ice cover in spring, which may reduce or eliminate the desirability of some sections for nesting because territorial defense sites may still be ice-covered with the initiation of the breeding season (Hinz 1974).

2. Ducks

Three effects on duck use of the Yellowstone River could be expected from a reduction of flows. First, reduced flow in the fall would decrease the extent and/or number of secure loafing sites, which would reduce the desirability of the river for use by ducks in the fall. Similarly, with reduced flows in the fall, the river might freeze over sooner in some areas, causing all waterfowl to migrate sooner. Also, in areas which now remain ice-free through most or all of the winter, ice cover may occur because of reduced flows, causing ducks which commonly use such stretches (mallards, goldeneyes, and mergansers) to winter further south.

3. Bald Eagles

Reduced flows in the Yellowstone River may cause it to freeze over sooner, which would force eagles along the river to migrate at an earlier date. As a result, many eagles which previously wintered in the valley or in the state might no longer do so. Aside from the physical changes in the river and their effects on eagles, the close ties of eagles with large numbers of waterfowl along the river would be affected. Eagles are thought to feed on crippled and lead-poisoned ducks and geese (as well as fish), and with a reduction in numbers of waterfowl using the river through the loss of desirable loafing areas, earlier freeze-up, and reduction in over-wintering flocks, the food supply of the eagles would definitely be diminished. Also, a reduction in fish biomass or a shift in species composition resulting from reduced flows would possibly be a disadvantage to eagles.

4. Other Water Birds

The effect of reduced water levels on great blue herons, pelicans and cormorants is purely hypothetical because so little is known about these birds on the Yellowstone River. Although water levels may concentrate fish in backwaters and other areas for a time, the reduction in fish habitat through lowered water levels would probably ultimately reduce the total food supply of these large, fish-eating birds.

B. Impact on Fisheries

The maintenance of the existing Yellowstone River ecosystem is completely dependent upon maintaining the natural flow regimes of the river system. Alteration of natural flow patterns will change the natural physical and chemical features of the river, which directly affect the biota.

Massive water withdrawals from the Yellowstone will have an effect on water quality (see Section 11.1.2.1.). Whether these withdrawals occur in a few large depletions or in numerous small withdrawals is irrelevant. What is important is the probably cumulative impact, and each individual withdrawal must be viewed in that context.

With an increase in population accompanying accelerated industrial development, the amount of organic waste entering the Yellowstone and its tributaries will increase if adequate treatment facilities are not present. In addition to concentrating the waste load of the river, the decreased discharge will have less capacity for the transportation of waste. Thus, sludge deposition would be expected to occur more readily.

Increased temperatures may result from lower flows. Relationships between temperature and the aquatic environment are intimate. Fish and other aquatic life are directly affected by water temperatures. The solubility of dissolved gases changes with increases in water temperature. Oxygen levels go down and oxygen requirements increase as temperatures increase. High temperatures and low dissolved oxygen concentrations will limit the variety of organisms present. Breakdown of organic matter also increases with higher temperatures and further reduces available dissolved oxygen. Water temperatures in the lower reaches of the river already approach critical levels, with summer temperatures in the 80's common. Withdrawal of water during this season would alter the heat budget of the river, and could result in lethal temperatures for fish like sauger, northern pike, sturgeon, and burbot, or for aquatic invertebrates and forage fish that support them.

One direct effect of reduced flow is lowered water velocity, which causes increased sediment deposition. Deposition of sediment in streams carrying a high sediment load greatly changes the environment by blanketing portions of the streambottom, and thus eliminating potential spawning areas and reducing the available food-producing areas. Increased discharge associated with spring runoff results in a flushing action which removes the deposited sediments. A discharge results in an annual cleansing of the streambottom and is an important aspect of the stream ecology, particularly for streams like the Yellowstone which transport large amounts of sediment.

Lower flows reduce important riffle areas, which in the Yellowstone are the areas of primary production. These areas are also lost due to sediment build-up associated with reduced velocities. All fish species of the river are dependent upon these areas of primary production, and without sufficient productivity at lower trophic levels, fewer fish and a lowered biomass will result.

Several species may require peak flows for migration and spawning. Paddlefish migrate up the

Yellowstone River each spring to spawn. Observations in Missouri indicate that paddlefish migrate in response to water temperature, day length, and an increase in flow level (Purkett 1961). The Yellowstone paddlefish run also occurs coincident with spring runoff (Robinson 1966). Strength of the spawning run is associated with the duration of the seasonal rise, rather than the height of the rise. The increase in flow may be necessary to trigger the run, allow passage of the migrant fish to the spawning areas, and provide adequate spawning habitat (Vasetskiy 1971). The spring rise must be maintained in the Yellowstone to meet the reporductive needs of this population of paddlefish.

Other spring spawners may also be dependent upon high spring flows. Sauger and walleye were found to be spawning during the spring rise in the Yellowstone River near Forsyth, and Olsen and Scidmore (1962) reported a correlation between the size of the sauger and walleye spawning run and the river stage height during the spawning run in the Ottertail River in Minnesota. These fish must also have areas of clean gravel or rubble bottom to spawn.

Northern pike require areas of flooded vegetation to spawn and as a nursery for young. Such areas only occur during peak spring flows in the lower Yellowstone, and these flows may be significantly reduced by massive water withdrawals.

Major flow reductions, in addition to adversely affecting the biota of the lower river, also significantly threaten the aquatic resources of the upper Yellowstone. Severe water demands placed on the river during critical low flow periods may necessitate flow augmentation in the form of main stem or off-channel storage reservoirs.

11.1.7. Radiation Impacts

11.1.7.1. Radiation Impact on Water Quality

The small amounts of uranium and thorium and their short-lived daughters released by the generating plants should pose little threat to water quality. Radium-226 is the radionuclide of primary concern to water quality.

The small amounts of radium released in generating plant stack effluents would not significantly alter the quality of Colstrip area surface waters. However, the disturbance of aquifer coal seams by strip mining may alter the radioactivity content of Colstrip ground waters. Present knowledge is not sufficient to predict the effect, but a significant increase is considered remote.

The greatest potential for Colstrip generating plant operations to cause a significant increase in concentration of radionuclides in surface and ground water is contamination from the ash pond.

Using the burning rate for area C coal (903,000 lbs/hr) and 0.3 pCi/g for the radium-226 concentration in the coal (dry wt. basis) and 95% removal efficiency of the scrubber (Section 8.4.), 87.5 x 10^6 pCi/hr reaches the ash pond along with 91,300 pounds of ash (all kinds). If the radium is all in the ash and all of the ash settles out of the slurry, the radium concentration in the ash would be about 2.1 pCi/g. Based on the same coal burning rate and assumptions shown in Section 8.4., the uranium and thorium concentrations in the ash pond ash would be 7.3 ug/g and 18.2 ug/g, respectively. These concentrations are those typically found in many sedimentary rocks (black shale in particular) and the more quartz-rich igneous rocks (granite and associated rock) (Moore and Swami 1972 and Haglund 1972).

The low solubilities of these elements would prevent rapid leaching of the ash. As with other contaminants, the radioactive materials cannot get into the groundwater if the ash pond is properly sealed and is not allowed to overflow.

Current knowledge does not permit accurate predictions of the amount of increase of the radioactivity content in surface and ground water which may result from generating plant operations. Any resulting increase should be only a small percentage of permissible concentrations if the ash pond is properly prepared and maintained.

11.1.7.2. Radiation Impact on Soil

The radiation impact on soil which would result from generating plant operations should be relatively insignificant. However, information is not available which allows accurate prediction of long range deposition of particles from the generating plant stack effluents. It is important to have a rough estimate of radium-226 deposition upon soil over the expected useful life of the generating plants.

Assuming the useful life of Colstrip Units 1 through 4 to be 30 years, approximately 3 curies of radium-226 could be expelled in stack effluents during this period of time. Although not a reality, if the radium were to be evenly deposited in a Colstrip concentric circle having a radius of 15 miles, and if the radium were evenly leached to a soil depth of one inch, the soil radium-226 increase would approximate 0.03 pCi/g which is approximately 4% of the expected natural radium-226 content of soil.

11.1.7.3. Radiation Impact on Vegetation

The radiation impact on vegetation in the Colstrip area is expected to be insignificant. The extremely small amount of airborne radioactivity in stack effluents which would be directly deposited upon vegetation and the resultant small increase in soil radioactivity should not produce a measurable increase over present levels of radioactivity in vegetation.

11.1.7.4. Radiation Impacts on Air Quality

The presence of radioactive contaminants in generating stack effluents is expected to result in a small, but measurable, increase in atmospheric radioactivity in the Colstrip area. This radioactivity may be transported by the atmosphere from the generating plants to humans and animals, soil, water and vegetation.

Radioanalysis of coal determined that radium-226 is essentially in equilibrium with uranium-238. To be conservative it was assumed that the other nuclides in the uranium-238 series, as well as the nuclides in the thorium-232 series, are in equilibrium with their respective parent nuclides. When in equilibrium, the activity of each daughter nuclide is the same as the activity of the parent nuclide.

Table 11-24 indicates the principal radionuclides in the uranium series and Table 11-25 the principal radionuclides in the thorium series. These tables also indicate the half-life and Maximum Permissible Concentration (mpc) (established by the AEC) of these radionuclides in air. In those cases where the mpc depends upon the nuclide's solubility, the more conservative value is used.

Because radium-226 is approximately midway in the uranium series and because the laboratory analysis for radium-226 is isotopically specific as opposed to the gross analysis for uranium, the activity of each nuclide in the uranium series is considered to have the same activity as radium-226. Nuclides in the thorium series are considered to have the same activity as thorium-232.

The emission rates for radium-226 and thorium for the proposed Colstrip Units 1 through 4 are given in Table 11-1 in Section 11.1.1.3A as 3.7 x 10^{-3} uc/sec and .0061 g/sec, respectively. Assuming the thorium to have the activity of thorium-232, its emission rate in terms of activity rather than mass was calculated to be 6.8 x 10^{-4} uc/sec.

As sufficient data to complete the short term dispersion modeling is not yet available (see Section 11.1.1.3C), the maximum probable 24 hour concentrations of the uranium and thorium series nuclides resulting from the emissions of Units 1 through 4 cannot be calculated. However, nuclide concentrations can be calculated for the conditions giving the maximum sulfur dioxide concentrations listed in Tables 11-5 and 11-6 (Section 11.1.1.3C), although the frequency of occurrence of those conditions is not yet known. The following table lists the maximum calculated twenty-four hour sulfur dioxide concentrations and the corresponding uranium and thorium series concentrations.

Table 11-26

Downwind Distance (km)	SO_2 ug/m^3)	Uranium Series uc/m^3)	Thorium Series uc/m^3)
0.5	6777[a]	9.0×10^{-9}	1.7×10^{-9}
0.5	1676[b]	3.6×10^{-9}	6.6×10^{-10}

a. Source Tables 11-5 and 11-6 in Section 11.1.1.3.C

TABLE 11-24

Principal Uranium Series Nuclides and Maximum Permissible Concentration in Air Above Natural Background

Nuclide	Half-life	MPC (air) uCi/m^3
Uranium-238	4.51 x 10^9 years	3 x 10^{-6}
Thorium-234	24.1 days	1 x 10^{-3}
Protactinium-234	1.17 minutes	1 x 10^{-4}
Uranium-234	2.47 x 10^5 years	8 x 10^{-6}
Thorium-230	8.0 x 10^4 years	8 x 10^{-8}
Radium-226	1602 years	2 x 10^{-6}
Radon-222	3.8 days	3 x 10^{-3}
Polonium-218	3.05 minutes	2 x 10^{-8}
Lead-214	26.8 minutes	1 x 10^{-4}
Bismuth-214	19.7 minutes	2 x 10^{-8}
Polonium-214	164 micro seconds	2 x 10^{-8}
Lead-210	21 years	4 x 10^{-6}
Bismuth-210	5.01 days	2 x 10^{-4}
Polonium-210	138.4 days	7 x 10^{-6}
Lead-206	Stable	—

TABLE 11-25

Principal Thorium Series Nuclides and Maximum Permissible Concentrations in Air Above Natural Background

Nuclide	Half-life	MPC (air) uCi/m^3
Thorium-232	1.41 x 10^{10} years	1 x 10^{-6}
Radium-228	6.7 years	1 x 10^{-6}
Actinium-228	6.13 hours	6 x 10^{-4}
Thorium-228	1.91 years	2 x 10^{-7}
Radium-224	3.64 days	2 x 10^{-5}
Radon-220	55 seconds	1 x 10^{-2}
Polonium-216	0.15 seconds	2 x 10^{-8}
Lead-212	10.64 hours	6 x 10^{-4}
Bismuth-212	60.6 minutes	3 x 10^{-3}
Polonium.212	304 nanoseconds	2 x 10-8
Thallium-208	3.10 minutes	1 x 10^{-8}
Lead-208	Stable	—

A comparison of the mpc of the uranium and thorium series nuclides in Tables 11-24 and 11-25 with Table 11-26 concentrations indicates that highest Table 11-26 values are about 45% of the lowest mpc value (Polonium-218, 2 x 10^{-8} uCi/m^3) for the uranium series and about 20% of the lowest mpc value (Thallium-208, 1 x 10^{-8} uCi/m^3) for the thorium series.

Because the short term modeling analysis is not yet complete, these values indicate, but do not prove, that the mpc nuclide values would not be exceeded for a 24 hour period by operation of Units 1 through 4.

The maximum annual concentrations of the uranium and thorium series nuclides obtained from the long term model analysis described in Section 11.1.1.3. are: uranium series, 3.7 x 10^{-11} uCi/m^3; and thorium series, 6.9 x 10^{-12} uCi/m^3. These values are well below the corresponding lowest values contained in Tables 11-24 and 11-25.

11.1.7.5. Radiation Impact on Human and Animal Life

There would be no external radiation hazard to human or animal health resulting from Colstrip generating plant operations. The only way that radioactivity released from generating plant operations could adversely affect human and animal health is if there should be inhalation or ingestion of significant quantities of this radioactivity. Preliminary calculations of twenty-four hour nuclide concentrations have indicated that Colstrip Units 1 through 4 emissions may not exceed the mpc in the air established by the AEC. The average airborne radioactivity levels over longer periods would be expected to be significantly less than the mpc values.

It was also concluded that any increase in the radioactivity of surface and ground waters would be only a small percentage of permissible concentrations if the ash pond is properly prepared and maintained.

It was further concluded that radioactivity released from generating plant operations should not produce a measurable increase over present levels of radioactivity in vegetation. Although over long periods some concentration of the radioactive elements may occur in the higher portions of the food chain, present knowledge is not sufficient to estimate the magnitude of that concentration. Consequently, it is not anticipated that human and animal food would be adversely affected by generating plant effluent radioactivity.

If generating plant effluent controls function as planned, there should be no significant adverse radiation impact upon human and animal health resulting from the operation of these plants.

11.2. Cultural Impacts

11.2.1. Impacts on Land Use Patterns

Existing land uses in the study area have been directly determined by yearly rainfall, available water and the length of the growing season. A paucity of each has resulted in an area of marginal productivity and small rural population supported by ranching and farming. This traditional agricultural land use pattern also incorporates an area (approximately 2% of total land area) of previously strip mined land. Urban land use has been concentrated at Forsyth, Colstrip, and Lame Deer; the rest of the study area is rural, with an estimated population density of one to two persons per square mile.

The land use impacts at Colstrip which would result from the construction and operation of Units 3 and 4 can generally be divided into those induced by 1) the plants and associated facilities, and 2) the increase in population. Land use is not a static, isolated process, but is constantly susceptible to fluctuations due to changes in climatic, environmental, economic, and social determinents. At Colstrip this means that power plant construction and operation are not solitary causes of land use change, and that, if the plants are built, they will determine a second series of land use changes in indirect response to the plants.

11.2.1.1. Impacts on Land Use Resulting from the Construction and Operation of the Plants and Associated Facilities

Landscape areas have qualitative images broadly defined by their inherent characteristics. The construction of Units 1 and 2 at Colstrip initiated the change in area character from agricultural to industrial. The erection of Units 3 and 4 and associated facilities would further reinforce that change. It is rare to find direct association of agricultural land to heavy industry; this phenomeon could cause a land-use buffering syndrome, in which intermediate land uses, such as storage areas and parking lots, separate the two.

Units 3 and 4 would occupy about four acres; with the addition of associated equipment and facilities scattered within an approximate half-mile radius, the total land occupied would be about 200 acres (see Section 8.1.). Such previous land uses as cropland, rangeland, and spoil banks would be eradicated during construction and operation periods.

Within two miles northwest of Colstrip, an approximately 150-acre surge pond is under construction, which will cover existing dry cropland and rangeland. Adjoining ponderosa pine savannah will be preserved, which could enable this industrial feature to also function as a recreation focal point, thereby further influencing land use adjacent to the surge pond.

About four miles southeast of Colstrip, an ash pond of a projected 356 acres is proposed. This area would functionally serve the plants for about twenty years, which indicates the need of additional land for a future ash pond within the approximately thirty-seven-year proposed plant lifetime. Rangeland and some pine savannah land would be immediately covered as the ash pond expands. A second, less definable impact on land use would result from the odor from the ash pond, which for the people living downwind could become a strong incentive to move.

The cumulative sum of the land uses discussed is 706 acres of proposed land use change. Associated equipment would preempt use of small amounts of adjacent land. This acreage would also require service roads, which would establish linear land-use patterns between the constituent elements. The construction of roads, upgrading of roads, and establishment of the other ingredients of the necessary spider web-like support system would cause nuisances such as dust, noise, and traffic delays.

Another downwind impact would be due to air pollution from the stacks. If emissions alter vegetative growth patterns or chemical composition of existing plants, responsive changes in rangeland, dry cropland, and irrigated land uses can be expected, but this impact is conditional based on the quality and quantity of emissions and the rate of accumulation.

The major physical factor affecting land use is not directly due to the siting of Units 3 and 4 and associated facilities, but is in direct response to the units. The demand for about 6,500,000 tons of coal per year would remove about 150 acres of land surface per year in order to run the plants at 80% capacity; during the life span of the plants, about 5,500 acres would be required to support the mining activity. The quality of and feasibility of reclamation will determine whether or not this is a permanent impact. A terminal impact would result on any one of the 63 archaeologic sites on the strippable coal's overburden.

The effect of strip mining on adjacent land uses is not known, but since other changes in land use are expected in response to coal extraction, it can be stated that the actual amount of land strip mined would not represent the total impact of land use changes. Nineteen wells and three springs would experience potential water quality and quantity changes (see Section 11.1.-2.2.B. "Alteration of Aquifers due to Mining Activity"), which would affect land use if human or livestock water sources are eliminated.

11.2.1.2. Impacts on Land Use Resulting from Increase in Population

The second series of impacts due to the construction and operation of Units 3 and 4 are based on a population increase to a predicted 16,000 people in Rosebud County by 1978; this number is projected to decrease for the operational phase of the plants, but will stabilize well above 1972's 6,400 inhabitants (see Section 11.2.2.1.). The scope of human impacts on land use are as unpredictable as are the people involved, but norms of previous human activity imply predictable trends.

The location and construction of housing is a preliminary need accompanying a population expansion. A February 1974 interview with Colstrip's Town Manager, Martin White, indicated that about 55% of the work force live in Colstrip, that about 13% live in the local area, and that about 32% travel more than 30 miles to work. The future validity of these precentages depends on the availability of housing in Colstrip and the locational preferences of the individuals creating the population increase. The Ken R. White Company's site plan for Colstrip expansion accomodates about 1800 people, with 243 acres to be used for housing and commercial and public services. However, this acreage does not allow for open space and the bicycle path system.

If a low-growth management is maintained for Colstrip (see Section 11.2.2.1.), the additional housing demand would revert to other existing populated areas, such as Forsyth, Miles City, and Lame Deer, or would be the impetus for new subdivisions for permanent structures or mobile homes. The lands adjacent to the major access route between Colstrip and Interstate 94, Route 315, would be most desirable for new housing.

The State Highway Department estimates a potential 2,500 vehicles per day would use Route 315 at peak Colstrip growth. This traffic would serve as a market for some commercial establishments and result in an additional change of existing land use.

One complex factor within the spectrum of human impact is the need for recreation. A proposed golf course and the proposed bicycle trail would satisfy some recreational needs, but only a segment of the over-all demand. "Outdoor recreation in America today is a major land use. It involves over a quarter of a billion acres of public land and perhaps as much private land" (Rotunno 1966, p. 46). The immediate vicinity of the generation sites and the town of Colstrip would experience increased recreational demand and user pressure on existing sites. The public sector would be faced with providing additional or alternate facilities and opportunities to relieve the pressure on existing sites. In the private sector, there would be an economic opportunity to provide facilities, but for the landowner, there is a potential conflict of interests. Many recreational pursuits, such as hunting, snowmobiling, motor cycling, and bird watching, involve a wide-ranging land use that presents the possibility of friction between the private landowner and the recreationist; subtle nuisances to the landowner would be created, such as gates left open or the presence of litter, which could eventually become a factor for land use change. These land use conflicts would result from both construction and operation of Units 3 and 4.

Historic and archaeologic sites have been located on the Recreation map located in Section 10.2.1. Any of these features which are disturbed by mining activities or supportive development would be irrevocably lost. A site is analogous to a piece in a puzzle, because its archaeologic significance is partially determined by its relation to other sites of similar age or location. The value of sites in the study area, which may now be considered unimportant, could therefore be dependent on future discoveries, to complete a picture of human occupation in the area. An impact affecting a larger area would be the exposure of the sites to more people. When historic sites are discovered, they begin to suffer the ravages of pot and bottle hunters; the buildings are altered by old-lumber seekers or vandals. A historic site's best protection is its anonymity, at least until proper research can be conducted and necessary controls established for preservation of the significant sites. The agencies which administer these sites may already be overextended, and those sites on private land would be even more vulnerable. The sites within view of present day acculturation, such as large power structures or associated strip mining, especially if close by, may have their integrity compromised even if the site itself is not disturbed. The presence of development could only inhibit an individual's ability to visualize the site as it was during initial occupation, and this is a factor of man's enjoyment of antiquities.

11.2.2. Social and Economic Impacts

11.2.2.1. Impacts on Population Growth

The population projections used in this report focus on Rosebud County alone. While coal development has stimulated some population growth in neighboring counties, over 80% of the current population growth has been located in Rosebud County. Given the long distances between communities in eastern Montana and relatively underdeveloped systems of transportation, it is anticipated that future population growth will continue to mirror that which has already taken place and will remain largely within Rosebud County. Thus, the projections contained within this report are for Rosebud County.

The projections should be interpreted according to the following assumptions.

1) Net migration will equal zero. This implies an equal number of in-migrants and out-migrants and that both categories share similar characteristics.

2) Population categories will continue to maintain their current nataling and mortality characteristics.

Population projections for the county are provided for total population in each county; non-white and white sub-populations in each county; sub-populations with less than high school attainment; high school graduation and more than high school graduation; and for occupational categories.

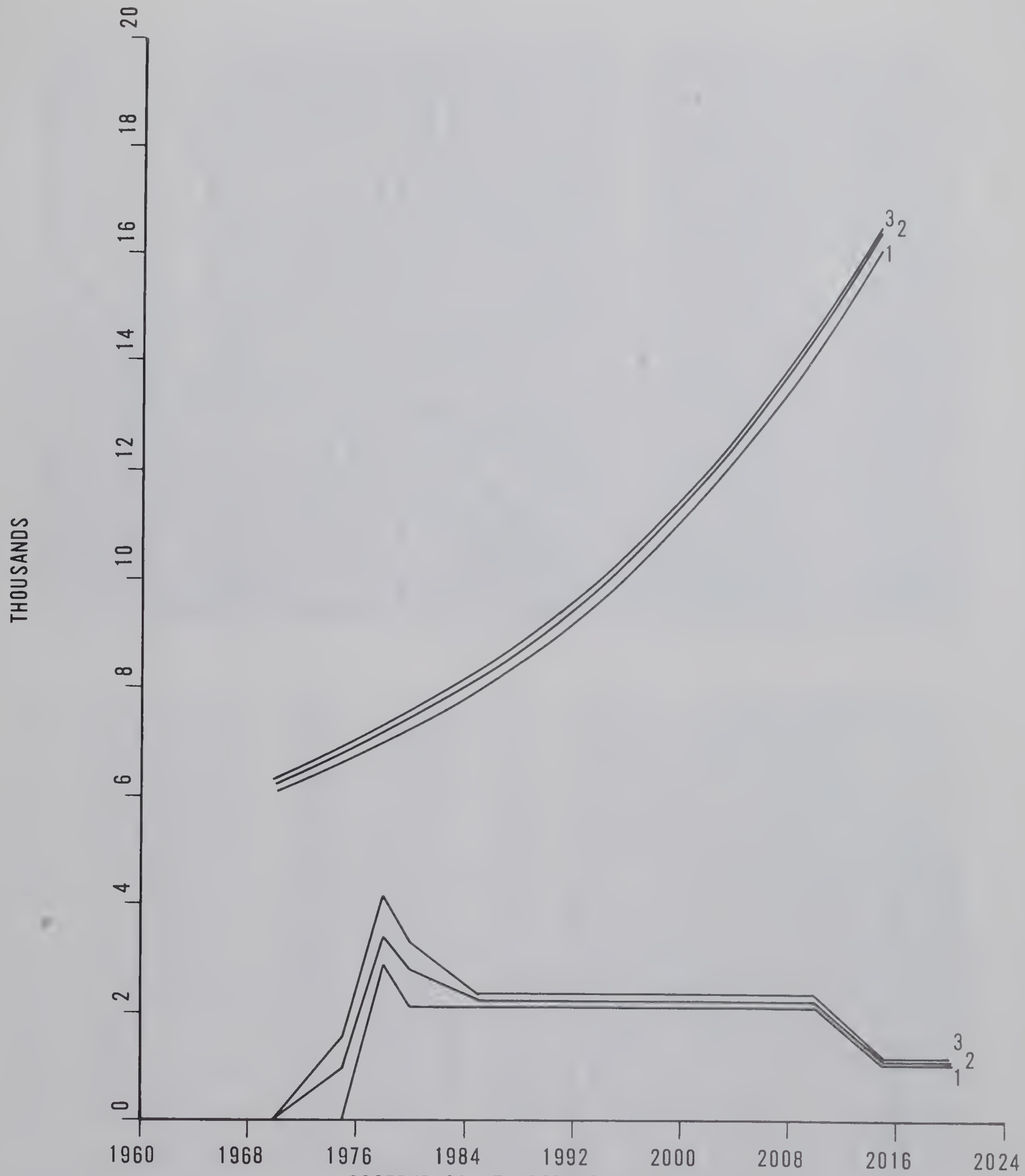
Three projections are computed for each population and sub-population indicating differing rates of population increase. Projection I reflects the lowest rate of increase, and is an expression of what the population would be if the age-sex structure and natality and mortality of the 1970 population remained unchanged. Projection II (labeled Assumption #1 on Figures 11-21 through 11-29) assumes a slightly younger, hence more rapidly growing, age-sex structure. Projection III (labeled Assumption #2 on Figures 11-21 through 11-29) reflects a still younger, and slightly longer living age-sex structure, hence the most rapid population growth of the three projections.

Associated with, and in addition to these sets of projections, are three growth curves computed for especially high population increase categories affected by the possible construction of Colstrip Units 3 and 4. These estimates of population growth appear on the bottom of relevant graphs (Figures 11-21 through 11-29). In order to obtain the highest probable growth for a time period, take the highest of the population estimates and add them to the highest population projection. Add the lowest population estimate to the lowest population projection in order to obtain the lowest probable population, given that Units 3 and 4 are constructed. Intermediate populations may be obtained by combining other combinations of estimates and projections. The Rosebud County overall population projection is shown in Figure 11-21.

A. Population Characteristics

1. Education

The primary assumptions made with regard to



ROSEBUD COUNTY POPULATION PROJECTION
1970–2020 1–NO EXTRA GROWTH 2–ASM#1 3–ASM#2
ASM = ASSUMPTION

FIGURE 11–21

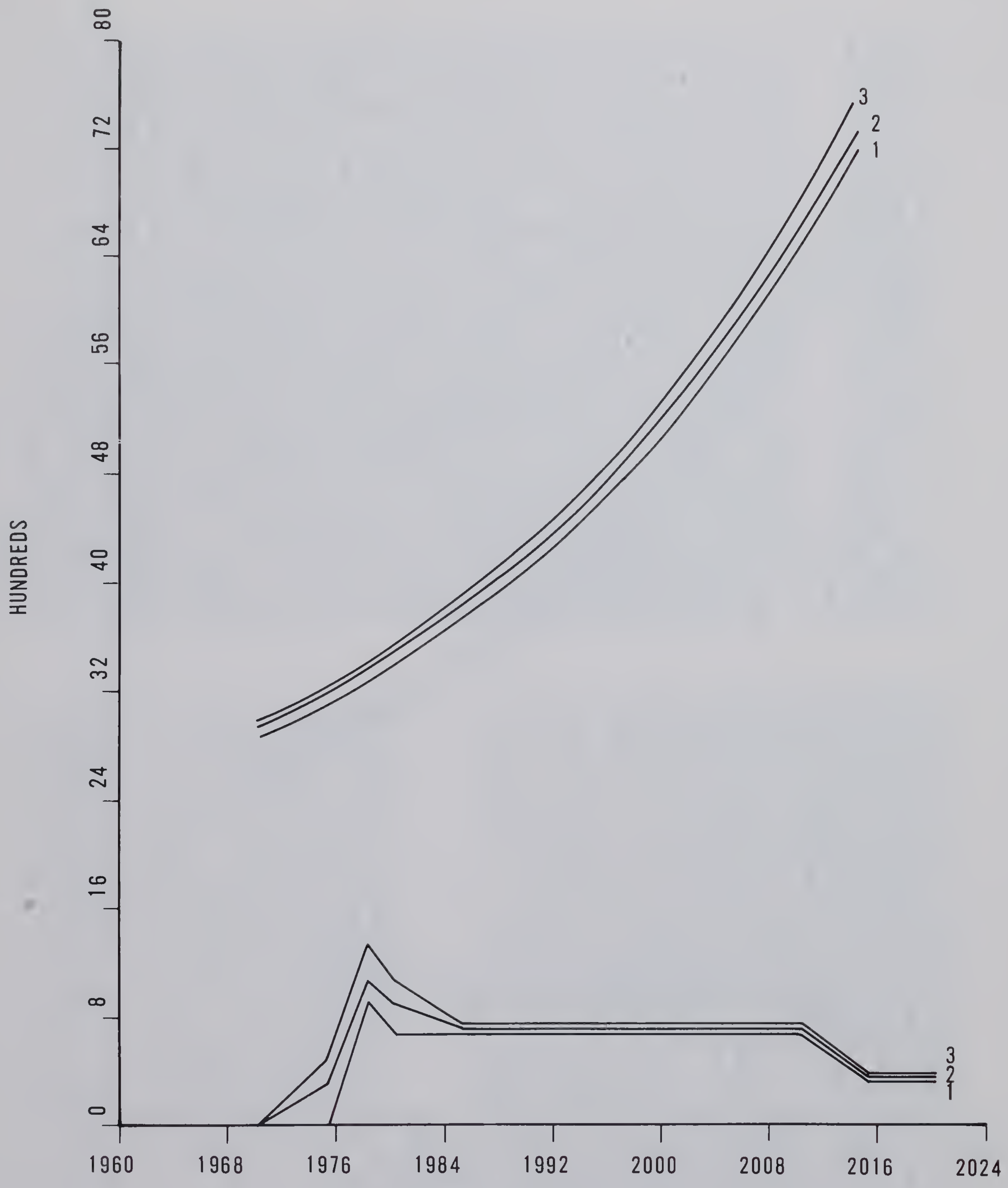
educational attainment are first, the educational achievement will remain essentially the same as it was in 1970, and secondly, that the members of each educational category are similar in age-sex and reproductive-mortality chacteristics. Each assumption is a simplifying one enabling comparative analysis to take place as if current conditions would extend into the future. In fact, educational attainment may increase among each of the categories and persons of differing educational attainment may acquire different age-sex and reproductive characteristics in the future. Educational categories include less than high school graduation (see Figure 11-22), high school graduation (Figure 11-23) and educational achievement beyond high school graduation (Figure 11-24). As for occupation, projections for education reflect the probable numbers of offspring of the 1970 population by levels of educational attainment for adult males.

2. Occupation

The primary assumptions made with regard to occupation are that occupational categories will continue to exhibit the proportions of members that they exhibited in 1970 and that the age-sex and reproductive-mortality characteristics will remain unchanged for each occupational category. Occupational categories are White Collar, which includes professional, managerial and kindred workers; Agricultural; and Other, which includes all manual, non-agricultural occupations.

Rosebud County has retained a relatively stable occupational structure during the period since 1950. Agricultural occupations have predominated as basic industry occupations. Professional and managerial occupations have provided services to large geographic trade and service areas relative to the small size of populations and municipalities within Rosebud and surrounding counties.

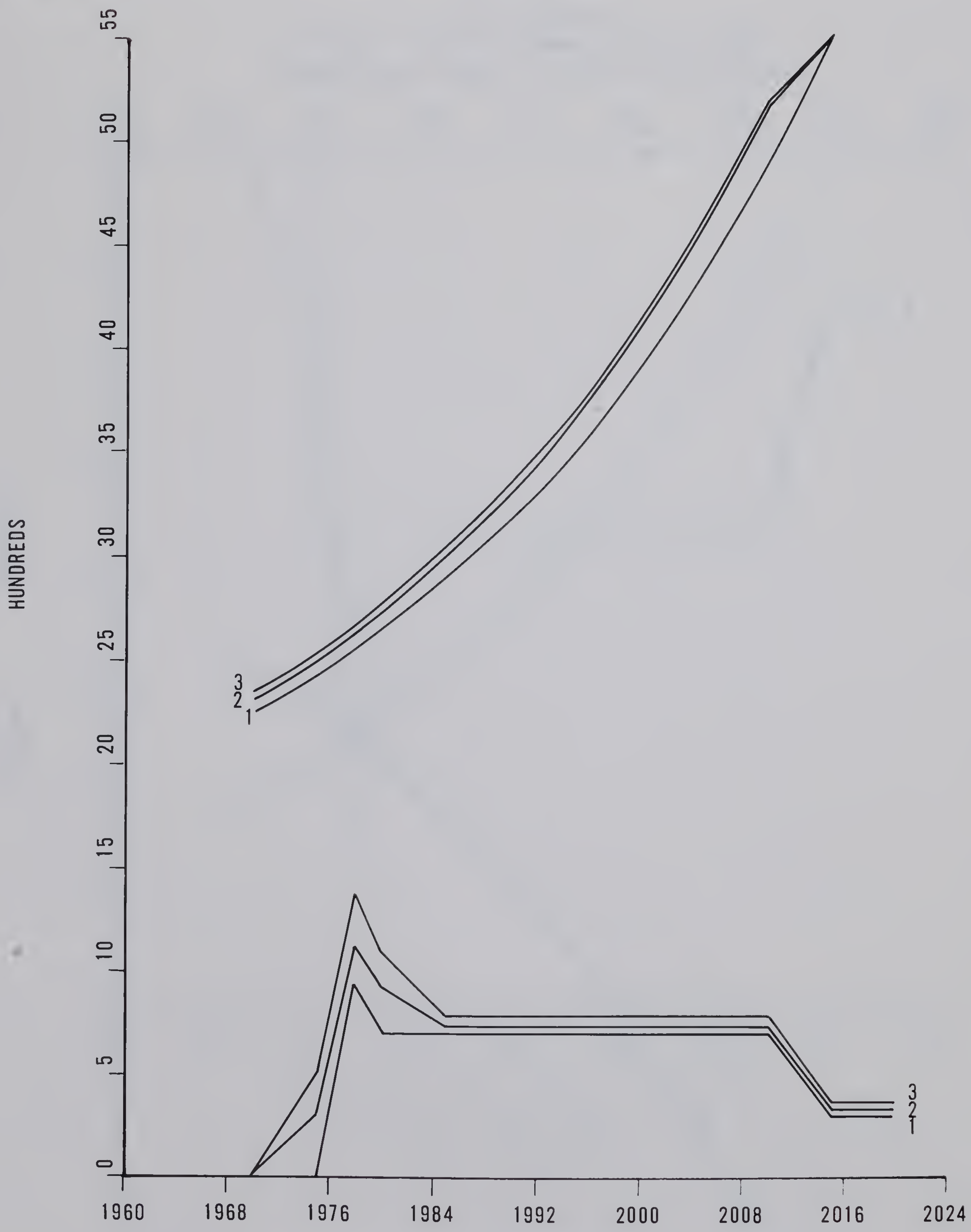
Projections indicate that if Colstrip's Units 3 and 4 become operational, the occupational structure of Rosebud County will be substantially altered. That is, whereas the number of agricultural workers has stabilized in the rural counties, the potential for nonagricultural employment is great. Consequently, agricultural workers can be expected to occupy a decreasing proportion of the workers in the county. The more rapid the non-agricultural expansion in the county, the more rapidly will the proportion of agricultural workers decline. This alteration in proportion of agricultural workers in the developing county populations does not necessarily mean that in-migrants will occupy the new jobs. Rather, it should be expected that persons who otherwise would have left the locality in order to obtain work elsewhere may now remain in non-agricultural positions. Indeed, if the offspring of persons in agricultural occupations remained in Rosebud County and obtained agricultural work, the county would gradually increase in population. Such expansion of agricultural positions is highly unlikely. If natality continues at this present rate, Rosebud County, like most of the counties in southeastern Montana, will continue to produce more children than can be employed in agricultural and secondarily related occupations. The following figures illustrate population projections for agricultural (Figure 11-25), professional (Figure 11-26), and "other" (Figure 11-27) occupations respectively.



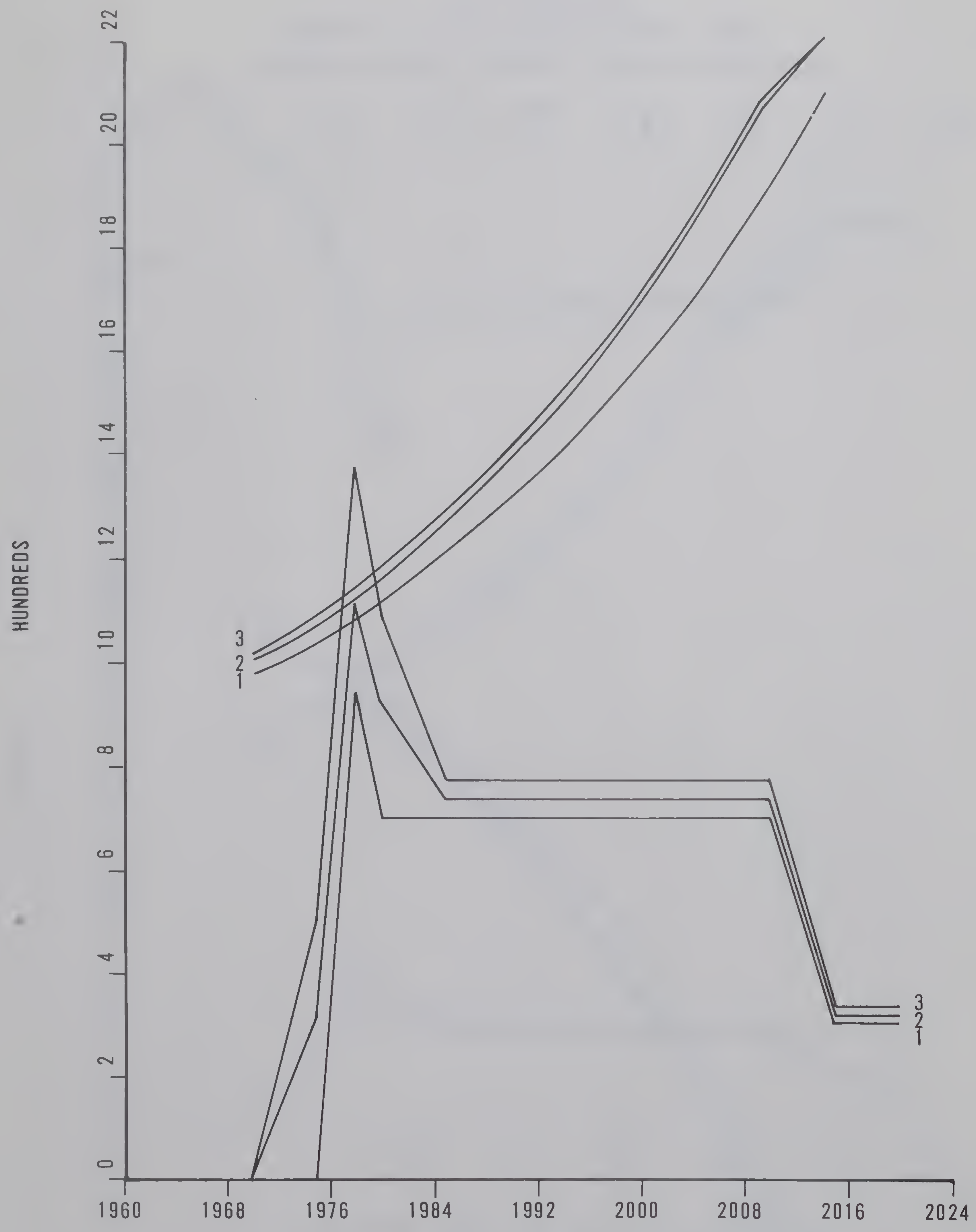
LESS THAN HIGH SCHOOL POPULATION PROJECTION ROSEBUD COUNTY

1970-2020 1-NO EXTRA GROWTH 2-ASM#1 3-ASM#2
ASM = ASSUMPTION

FIGURE 11-22

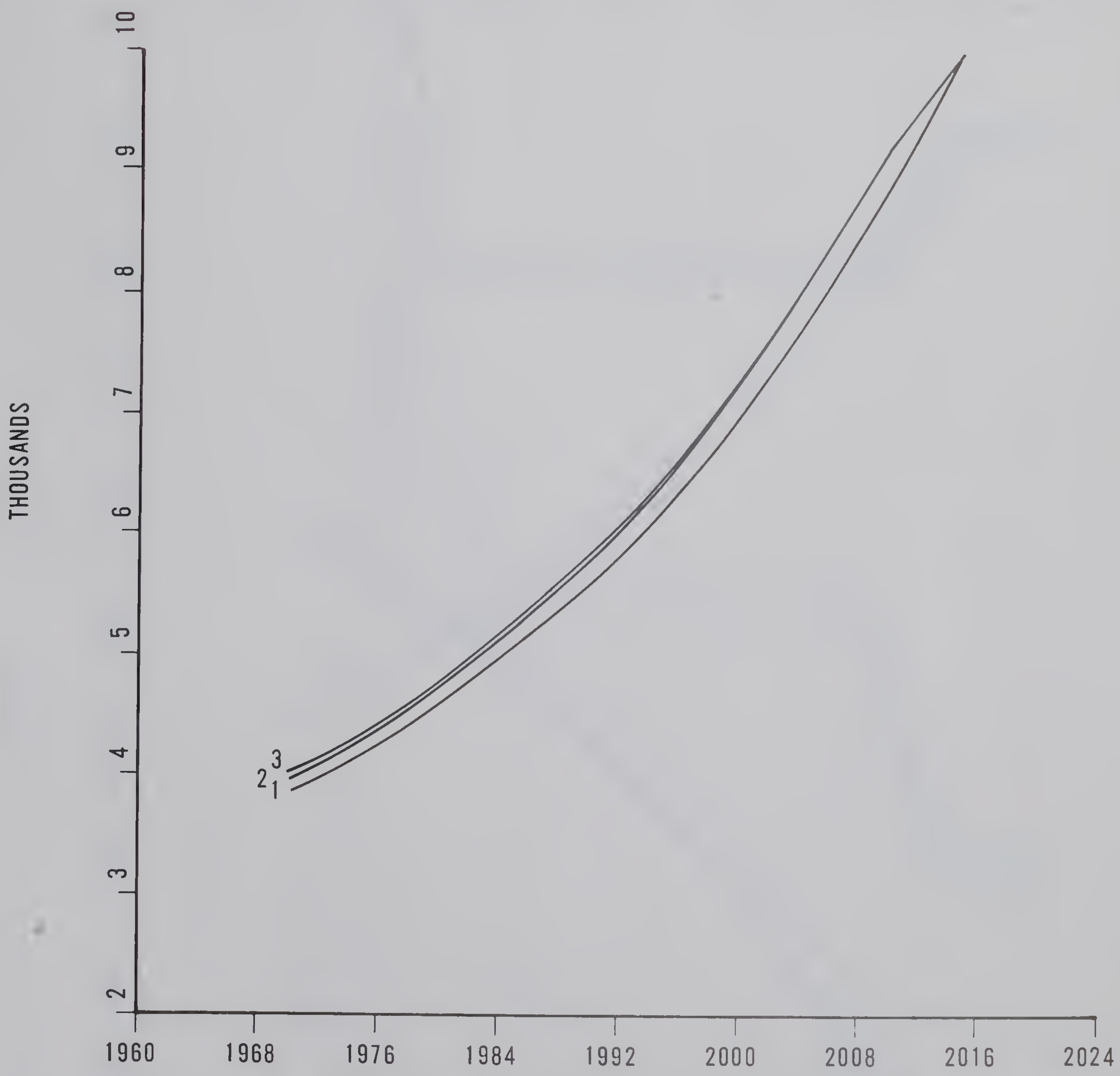


ROSEBUD HIGH SCHOOL·GRADUATE POPULATION PROJECTION
1970–2020 1–NO EXTRA GROWTH 2–ASM#1 3–ASM#2
ASM = ASSUMPTION
FIGURE 11–23



ROSEBUD HIGH SCHOOL PLUS POPULATION PROJECTION
1970–2020 1–NO EXTRA GROWTH 2–ASM#1 3–ASM#2
ASM = ASSUMPTION

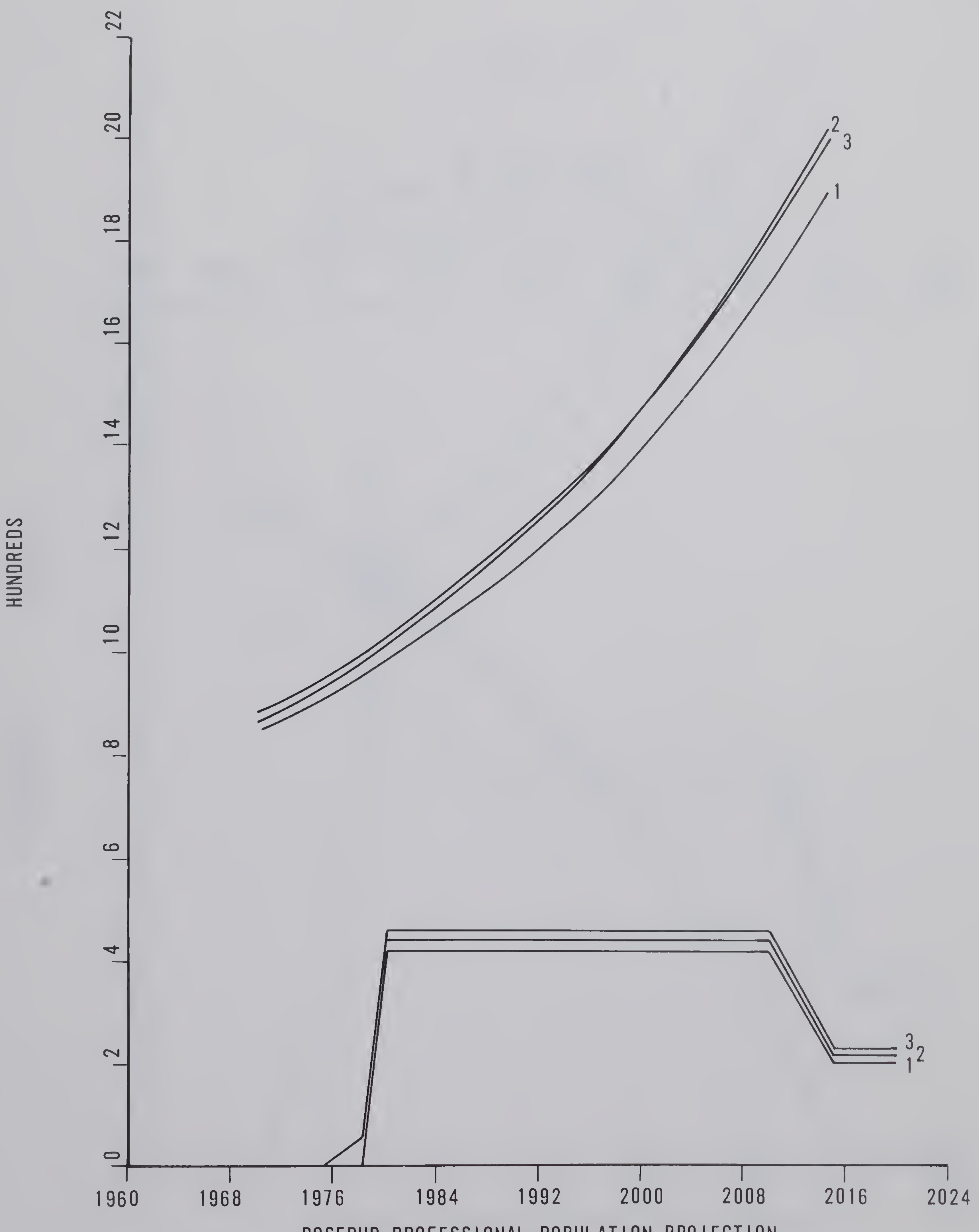
FIGURE 11–24



ROSEBUD AGRICULTURAL POPULATION PROJECTION

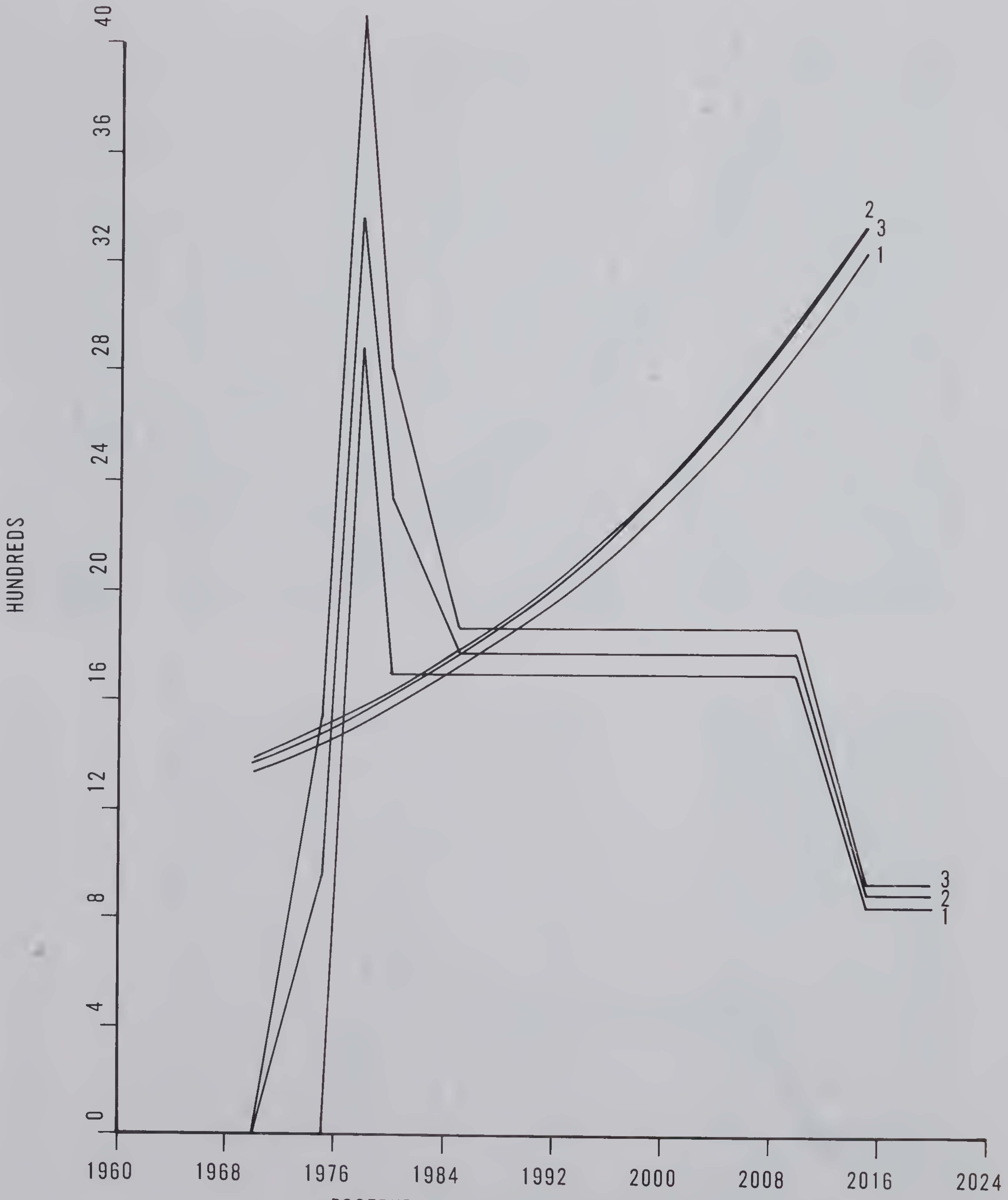
1970-2020 1-NO GROWTH 2-ASM#1· 3-ASM#2
ASM = ASSUMPTION

FIGURE 11-25



ROSEBUD PROFESSIONAL POPULATION PROJECTION
1970–2020 1–NO EXTRA GROWTH 2–ASM#1 3–ASM#2
ASM = ASSUMPTION

FIGURE 11–26



ROSEBUD OTHER POPULATION PROJECTION
1970–2020 1–NO EXTRA GROWTH 2–ASM#1 3–ASM#2
ASM = ASSUMPTION

FIGURE 11–27

Occupational categories should be interpreted from a special perspective. Projections indicate what the size and structure of occupational categories would be if offspring followed in the occupational footsteps of their parents. That is, the size and structure of the progeny are being projected for each occupational category. These sizes and structures should not be interpreted as if the offspring will occupy such occupations when, in fact, many (and perhaps most) will take occupations different from their progenitors.

3. Race

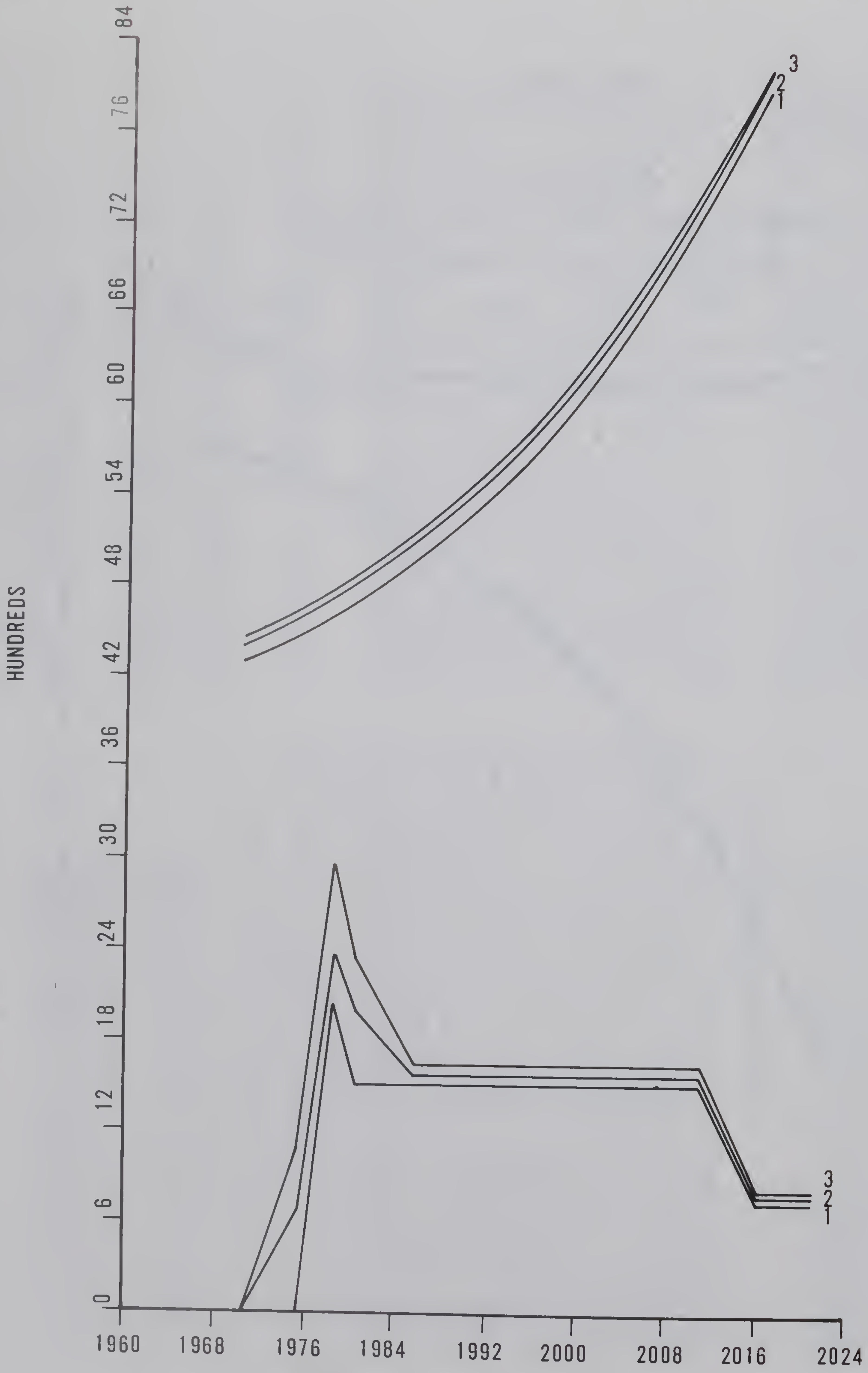
Races have been divided into white and non-white categories. The assumptions related to race which have permitted projections to be established are that currently existing age-sex and reproductive characteristics of the racial groups are similar. In fact, the non-white category, represented almost entirely by Indians, have a younger age structure and, consequently, higher reproduction than do whites. For counties with small non-white populations this presents little problem for projecting accurate populations. Nor do these assumptions affect the projections for total populations. Comparative long-term growth rates of the racial categories may be biased toward excessively high natality within the white category and lower natality than probably will be observed for the non-white category. The white and non-white population projections are shown in Figures 11-28 and 11-29.

B. The Future

Current indications are that Rosebud County is being and will continue to be affected more by coal development than are the adjoining counties for some time to come. Extensive development already is underway and promises to increase if coal becomes an increasingly important source of fuel for the region and nation. The demographic impact of this development will be extensive. The percentage increase of the population was around 30% between 1970 and 1974. Although this rate of increase will be reduced as the population base increases, a high rate of growth will continue through 1978 or 1980, especially if Units 3 and 4 are constructed.

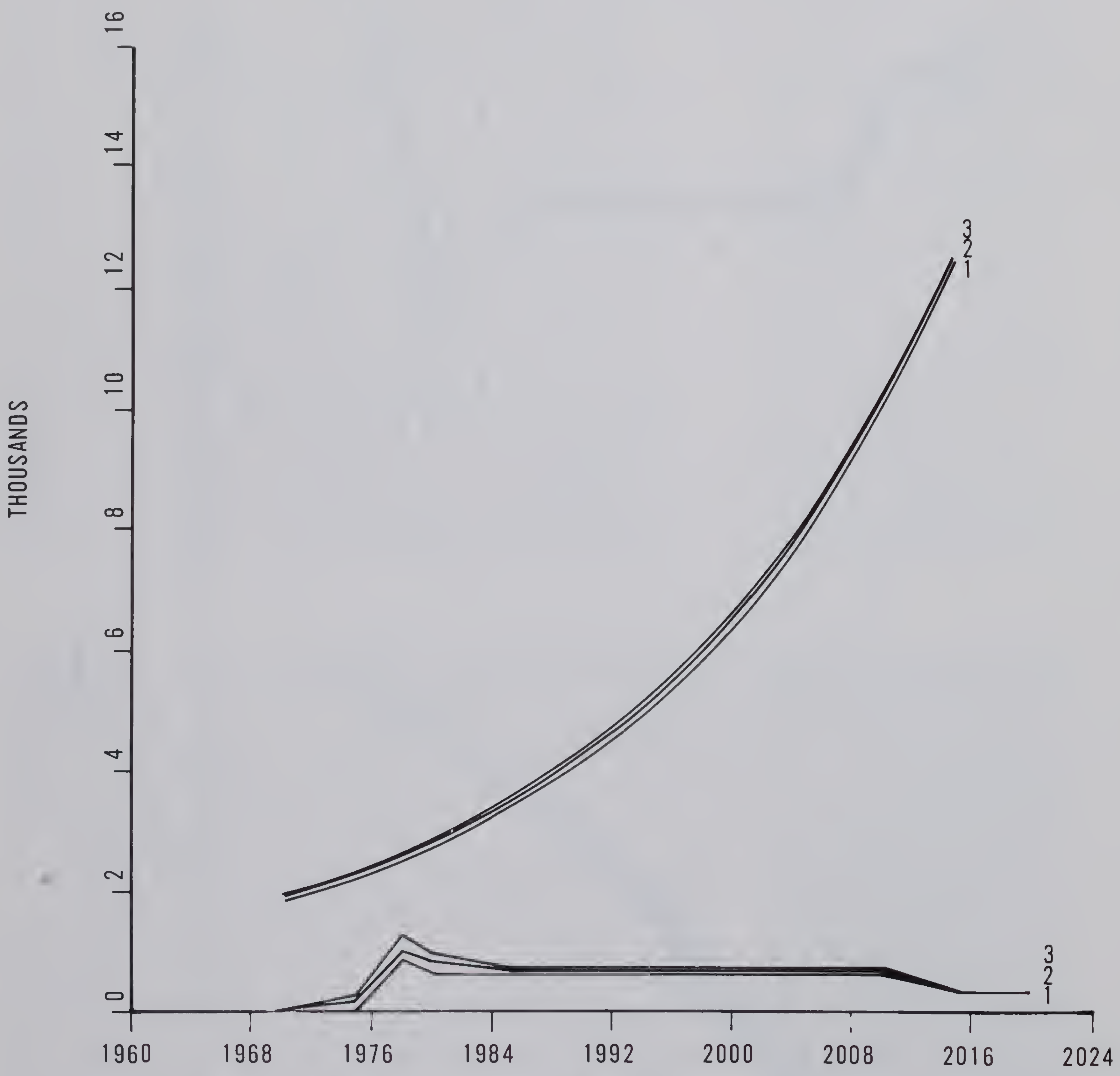
Besides increases in the overall size of population, the distribution and composition of the population also will be altered. The center for greatest and most rapid growth will be Colstrip. Other municipalities, especially Lame Deer and Forsyth, also will attract population. More than merely attracting new population, however, the development will permit many current residents to remain instead of moving away from Rosebud County. Rosebud County already has a relatively youthful population. As the population rapidly increases, this youthful composition will be maintained. In time, as the construction jobs are finished and permanent jobs become the primary income sources, the population will become slightly older than it will be during the peak growth period. Natality probably will be reduced very gradually and the population should stabilize by the turn of the century.

The proportion of persons in occupations also can be expected to change. Blue collar employees, at first construction and later operation and maintenance personnel, probably will become the largest proportion of the labor force. The proportion of professionals and management



ROSEBUD WHITE POPULATION PROJECTION
1970-2020 1-NO EXTRA GROWTH 2-ASM#1 3-ASM#2
FIGURE 11-28

ASM = ASSUMPTION



ROSEBUD NON-WHITE POPULATION PROJECTION
1970-2020 1-NO EXTRA GROWTH 2-ASM#1 3-ASM#2
ASM = ASSUMPTION

FIGURE 11-29

personnel also can be expected to increase as the expanding population requires additional administration, goods and services. The proportion of persons employed in agriculture will decline although the absolute loss of agricultural jobs probably will not be great.

The creation of this new occupational base could well increase the economic and educational averages for the county. However, the sub-populations with lowest incomes and educational achievement, the aged and the minorities, probably will continue to have lower than average incomes and education unless provisions are made which would reverse past trends. The high fertility among the non-white population cannot be expected to be rapidly reduced, thus the percentage of non-whites should be stable in spite of in-migration of white persons. Unless economic opportunities are obtained by this segment of the population, rising county averages may mask the continued low economic and educational position of the Indians.

In making these projections, three separate population categories were used.

1) Base population, which refers to the indigeneous population of Rosebud County as of 1970 with additions for natural increase because of natality, mortality, and changing occupational, age, and sex structure.

2) Direct employed permanent population (hereafter referred to as direct population) which refers to workers and their families who will hold jobs as operational personnel at the mines and in generating plants in Rosebud County.

3) Construction population, which refers to personnel employed in the construction of the generating units and their families.

1. Base Population Forecasts

The base population forecasts (shown in Tables 11-27, 11-28 and 11-29) were developed on the assumption that other major coal development in addition to that at Colstrip will occur in Rosebud and surrounding counties. By creating new basic employment for residents of Rosebud County who might otherwise move, and by causing an influx of new residents, these additional development activities would offset the out-migration that has previously occurred in Rosebud County. The forecast, then, is a direct projection of the 1970 population, assuming both no out-migration and continued reproduction at the 1970 rate. Short-range fluctuations in the base population due to construction activity at Colstrip are not reflected in the base population forecasts because these fluctuations would be very temporary and extremely difficult to predict.

Three additional statements should be made:

1) It is assumed that school-age children would constitute 30% of the base population./21

2) Most of the workers and their families directly employed in the construction of Units 1 and 2 are not included in this forecast.

TABLE 11-27

ROSEBUD COUNTY POPULATION PROJECTIONS WITH THE CONSTRUCTION OF UNITS 1 AND 2 AND ASSOCIATED MINE EXPANSION

	1970	1975	1978	1980	1985	1990	1995	2000
Total[1]	6,032	9,357	8,137	7,862	8,563	9,337	10,253	11,367
Base[2]	6,032	6,501	6,818	7,117	7,818	8,592	9,508	10,632
Direct[3]			745	745	745	745	745	745
Construction		2,111	574					

[1] See proceeding discussion for a description of the assumptions on which these forecasts were based.

[2] Base population forecasts include the 1970 Rosebud County population projected to the year 2000. Included as base population are the families of the approximately 33 WECO personnel working at Colstrip in 1970.

[3] This forecast assumes 250 mine personnel and 60 personnel operating Units 1 and 2 (Westinghouse, 1973). Correction has been made for the 33 WECO personnel counted in the Base population category. The projections also incorporates a 5% expansion figure (i.e. the 1975 WECO Work force will total 325 men).

[4] This forecast assumes 1103 construction personnel on the job in 1975. This figure is 5% addition to the figure of 1,050 men reportedly working on construction at Colstrip as of September 13, 1974. Manpower estimates supplied by the Billings Office of the Montana Employment Service. The construction related forecast for 1978 assumes 300 men on the job completing the final details of construction.

TABLE 11-28

POPULATION PROJECTIONS FOR ROSEBUD COUNTY WITH THE CONSTRUCTION OF UNITS 1-4 AND ASSOCIATED MINE EXPANSION

	1970	1975	1978	1980	1985	1990	1995	2000
Total	6,032	9,357	11,849	9,374	9,501	10,245	11,191	12,305
Base	6,032	6,501	6,818	7,117	7,818	8,562	9,508	10,622
Direct[1]		745	1,683	1,683	1,683	1,683	1,683	1,683
Construction[2]		2,111	3,348	574				

[1] This forecast assumes 325 permanent workers in 1975 and 693 permanent workers in 1978. The latter figure is then stabilized to reflect full production at Colstrip.

[2] This forecast assumes 1103 construction workers in 1975, an employment peak of 1750 construction personnel in 1978. Tapering to 300 in 1980, and dropping to zero thereafter.

TABLE 11-29

ILLUSTRATIVE DISTRIBUTION OF PERMANENT ROSEBUD COUNTY POPULATION[1]

	Alternatives			
	Low Impact on Colstrip[2]		High Impact on Colstrip[3]	
Area	1980	1985	1980	1985
Rosebud County	8800	9501	8800	9501
Colstrip	2500	2500	3500	4000
Forsyth	2800	3500	2300	2500
Lame Deer	1200	1500	1200	1300
Rural	2300	2001	1800	1701

[1] These alternatives are merely illustrations of the potential effect Western Energy decisions might have on the population distribution of Rosebud county.

[2] This alternative assumes: 1) that WECO will limit the population of Colstrip to 2,500, resulting in a high population increase at Forsyth, and a moderate increase at Lame Deer; and 2) our migration from rural areas of the county will occur.

[3] This alternative assumes: 1) that major coal related population increases will be concentrated at Colstrip; 2) that moderate population increases will occur in Forsyth and Lame Deer; and that our migration from rural areas of the county will occur.

3) Most of the permanent new population resulting from mining and plant operations at Colstrip were not included in this population forecast.

2. Direct Population Forecast

Full mining and plant operation at Colstrip will result in a new permanent population of workers and their families. The permanent employment at Colstrip is predicted to be 693 by 1980./22 The following assumptions were made to derive the estimates of the direct permanent population.

1) None of the new permanent employees would be over the age of 64.

2) Eighty-five percent of these workers and their families would reside in Rosebud County.

3) Eighty percent of the workers would be married and have an average of 2.5 dependents each (1.5 children and 1 spouse).

4) School-age children would constitute 30% of the new permanent population./23

3. Construction Population Forecasts

Construction activity on Units 3 and 4 would create a temporary population influx. The peak construction employment at Colstrip is predicted to be 1,750 and would occur between 1977 and 1979./24 The following assumptions were made to derive the estimates of the construction population:

1) None of the construction employees would be over the age of 64.

2) Eighty-five percent of the new construction workers and their families would reside in Rosebud County.

3) Fifty percent of these workers would be married and have an average of 2.5 dependents (1.5 children and 1 spouse).

4) Each married worker would have an average of 1.1 school age children./25

Three qualifications with regard to the population projections must be indicated. First, for the years 1975 and 1978, the "direct" population forecast assumes that the operating mine and power plant personnel will be on the job or located in Rosebud County in training for their future employment. As such, the population projections for this category of workers may be slightly inflated since the requisite construction will not be completed, and the operating work crews may not have reached the full employment peak.

Second, the population projections derived for the construction personnel are tenuous, at best. Labor disputes, difficulty in receiving necessary construction materials, changing conditions in the labor market, and a host of other factors subject construction projects to radical changes in the size of their labor forces. The projection of 1,750 construction personnel in 1978 is approximately 100 men higher than the maximum projected by the Westinghouse Report (1973). However, if the project experiences a growth in its construction labor force similar to that at the Bridger Power Plant in Rock Springs, Wyoming, then even 1,750 construction personnel will be extremely low. The Bridger project predicted a maximum of 1,200 workmen, but 3,000 men were required ("Rock Springs, Wyoming" 1974, p.5). A similar phenomenon in Colstrip using the Westinghouse (1973) figure, of an employment maximum of 1,658 construction personnel would indicate a 1978 peak of 4,145 men and a total construction population of 7,927. If the base and direct population of Rosebud County are added to this figure the total 1978 peak population would be 16,428.

Finally, the population projections of this section do not contain an employment multiplier. As such, the projected populations are based on rates of natural increase and in-migration to construction, mine, and power plant jobs. The population effects of secondary employment are neglected. It is implicit in these projections that a large portion of the secondary employment opportunities will be filled by residents of Rosebud County. For example, the wives of construction workers may work as waitresses, beauticians, and so forth. Also, given the small size of the communities in Rosebud County, a portion of the secondary jobs, especially those of a specialized nature, may be located in the urban areas of Miles City or Billings. Thus, while it is acknowledged that secondary employment may lead to additional in-migration and population increase, its total effect is yet unspecified.

Given the qualifications attached to the population projections of this section, it is suggested that the figures contained in Tables 11-27 and 11-28 be interpreted as a low population forecast. Changing demands for construction personnel may sharply increase and grossly inflate the county population./26 Furthermore, the effects of secondary employment are unspecified and may add to an increase in the population of Rosebud County.

The population projections contained in this section are at variance with those located in Section 11.2.2.4. The difference is explained by the different assumptions under which each set of projections was conceived. The projections of this section reflect a social perspective with population growth primarily a product of the mortality, natality, and migration. The projections of Section 11.2.2.4. reflect an economic perspective. That approach largely draws its conclusions about population growth by estimating employment opportunities and assuming in-migration to fill each available job opening. In examining each set of population projections it is important to keep these distinctions in mind. A primary difference between the two sets of projections is that the social perspective does not contain a multiplier for population growth associated with secondary employment. With every increase in primary employment some secondary employment is also induced, and, in most cases, there is some in-migration to fill such jobs. Thus, by ignoring the effects of secondary employment, the population projections made from the social perspective should be considered a low estimate of population growth. On the other hand, the economic perspective with its implicit assumption of in-migration to fill all secondary employment opportunities, ignores the fact that many secondary jobs are filled by local residents. Thus, the population projections from the economic perspective (Section 11.2.2.4.) should be considered a high estimate of population growth.

11.2.2.2. Impacts on Social Structure

For the people of Rosebud County, the issue is coal development in all its unpredictability and forms, not just the addition of one or more generating units. It would therefore be erroneous to attempt a separation of impacts that are caused by the various phases of coal development, especially when the people directly involved do not make hard and fast distinctions. Since ethnography attempts to describe and explain a social situation using the perspective of the participants, this section necessarily deals with the entire spectrum of coal development together with the impacts of Units 3 and 4. The following discussion is built upon ethnographic data collected at Colstrip and its surrounding environs (Rosebud, Big Horn, and Powder River Counties) during 1973 and 1974.

A. Results of Ethnographic Study

1. The Reactions of Ranchers

a. Ranchers in the Study Area

The majority of ranchers in southeastern Montana interviewed to date are against all-out coal and energy development and would in fact prefer that such development cease. As a group, these are mostly younger men who have inherited and are upholding a family tradition of cattle raising. They are traditionalists. Although many run very large and profitable ranching operations, others have smaller spreads and are doing less well economically. While limiting development to strip mining might be tolerable, they and their hired hands think the whole business is wrong. They are committed to maintaining the land and its integrity and they unswervingly devote themselves to a ranching life-style, regardless of the fact that for some (hired hands especially) a different career would probably be more lucrative. Many feel that if they do not fight development they are faced with the unpalatable and uncertain prospect of selling out and relocating. Many consider leasing unthinkable because they believe that it would lead unalterably toward massive industrialization and that the economic benefits would be far outweighed by the social problems and costs.

Those who favor development constitute a divergent group. There is some evidence that they usually do not have the same family ties to the area as do their neighbors. Some are reportedly poor managers who are trying to regain their losses or get back at unproductive land. They also believe that the land will not be totally and irrevocably destroyed. The general view is:

> If we can send people to the moon we can figure out how to reclaim the land. We could improve it by putting coal money into leveling and irrigating it. In the long run, coal development is good for the land. In the short run, coal development will certainly mess up the land and some damage will be irreparable, but we should be able to live with it.

Such individuals expect to be able to continue to ranch and to again lease or repurchase their land after mining has taken place, which they believe will require a relatively short period./27 The researchers doubt that persons in this or any other group in the study area fully comprehend what could lie ahead with the possible number of plants and influx of population. Having seen only a very small segment of development so far, they find it hard to imagine the real consequences entailed. One interviewee contends that this closing of eyes to the future, whether intentional or unintentional, makes it easier for pro-development ranchers to "justify their greediness" in getting money from coal.

Who is for or against coal development is not simply a matter of who has fee coal (i.e., coal which belongs to the surface owner) underneath his land. Although the presence of coal may well be a factor, it does not fully explain ranchers' views, since several who are opposed to development possess coal and have been offered a great deal of money for it. A partial explanation is that those who tend toward being pro-development usually defend their view in the publicly acceptable terms of being obliged to help the nation deal with its energy crisis: there is a need for development, and it presents a challenge. Anti-development people do not accept the assumption that western coal mining and conversion is needed to solve the energy crisis, pointing out that coal closer to the source of need could be mined (e.g., in Appalachia), that coal in the Fort Union Basin could be deep mined and exported to appropriate metropolitan areas, and that solar or wind power could be developed to meet energy needs — all without requiring people like themselves to pay terrible social costs for short-run energy benefits.

Very few persons believe that coal development and ranching can go on side by side. Individuals who so believe are mostly older persons, although a few of the younger ranchers are known to take this optimistic view. Those who subscribe to this belief seem to feel that there is money to be gained from coal, and one might as well take advantage of it. However, most landowners interviewed find the likelihood of large-scale energy development constantly threatening. There is a great deal of uncertainty about what is going to happen and a great deal of dissatisfaction concerning the actions of the companies and corporations involved.

In the past, ranchers tended to identify strongly with big business. Those who are against development are rapidly becoming disenchanted with big business because they perceive that many valued natural resources will be destroyed as a by-product of the activities of power, coal and railroad companies. For example, they believe that the flattest and best agricultural lands tends to be the initial site of mining operations./28

Some ranchers believe that power and coal companies are unfair, untrustworthy, and inconsiderate, and that they receive preferential treatment from various public agencies. For example, interviewees note that the big companies pay less for utilities than do small ones or individuals, although one person felt that this situation was defensible. Thus far, these firms have given the appearance of paying less than their share of taxes. Coal and power companies bring about school and other problems but feel no obligation to do anything to forestall or solve them; /29 as one informant stated, "We pay the costs and the company reaps the benefits." The companies also reportedly misrepresent their intentions for development -- for example, about power line placement plans and commitments./30 Their statements are just not considered believable. Interviewees have also noted that the companies have said they "don't know" when later it was revealed through public declaration or overt action that in fact plans had been made. Ranchers typically report that the coal companies are deceitful and appear to be interested solely in making money; providing a service is of secondary importance. One rancher said:

> Mining companies make fools of us. They always lie about what they're intending to do and how much of it they indend to do. They are sneaky, deceptive, and so on. They get you to sign easements through lying and then it's too late to get a fair deal.

Landowners report that coal, power, and construction company officials are attempting to bluff, coerce, and even intimidate the locals into doing their bidding and that the situation amounts to a kind of war in which all is fair and the locals or landowners are viewed as the enemy.

Some interviewees note that farmers and ranchers make the mistake of treating corporations as people, but the companies are not at all likely to react as normal persons do. Corporations, it is said, are amoral, cold-blooded, and so profit-oriented that they feel no loyalty or obligation to their country, to mankind, or to anybody but themselves for the most part. Many of those interviewed recalled the good reputation of Northern Pacific and remembering that, had initially assumed mining and coal corporations would be just as good./31 This favorable attitude gave coal and mining corporations a great advantage which they promptly took, these persons lamented.

Valuing credibility, trust, and honesty, the ranchers see themselves as being greatly handicapped when they must deal with others whom they consider less than honest, trustworthy or credible. Ranchers still tend to use values and related behavioral assumptions which they developed through less stressful, "live and let live" circumstances, although the situation is now full of conflict. Ranchers find that these value differences create much anxiety, uncertainty, and difficulty in dealing with corporation tactics.

One of the favorite "tricks" (respondent's word, not the author's) of companies is to send out surveyors without first asking for the appropriate permission. If they are discovered and asked to leave, the surveyors simply get out. In the meantime they've probably accomplished much of their task without securing the proper authorization or even attempting to do so. Oftentimes, interviewees suspect, the surveyors are able to go in and out without ever being noticed because the land holdings are so vast.

Another favorite "ploy" (again, respondent's term) of companies frequently noted by interviewees is to begin construction work before getting formal permission to do so. The companies then argue that, because of the substantial commitment they have made, permission should be given to mine coal or construct power lines. Securing approval for a reservoir (for recreational, aesthetic, agricultural, and...industrial purposes) appears to be a "ploy" for obtaining permission to establish a gasification plant. Some ranchers believe that coal companies establish inroads by buying or leasing key places, developing scare rumors, and employing pincer movements to lop off large chunks of land for development. Locals naturally resent the employment of what they see as devious tactics.

Interviewees described the experience of unexpectedly receiving a land condemnation threat as terrifying. The question was raised as to whether such notices were being used to scare hostile ranchers into giving up the fight against coal development. Upon receipt of such a notice, one has to hire lawyers and spend a lot of time and money in trying to defend what has legally and rightfully been one's own land all one's life. Another scare measure which has reportedly been used extensively in companies' attempts to acquire land involves pointing out to a rancher what will happen to him if a neighbor decides to lease. He is then encouraged to go along with what his neighbor is presumably about to do. Another tactic which is in constant use is speaking in terms of when various developments occur, rather than if — a practice noticed by both respondents and researchers. Locals note that this usage tends to make them feel powerless and at the mercy of uncontrollable external forces.

Ranchers are keenly aware of the tremendous power, both financial and political, held by the industrialists. For example, progressive ranchers are those who continually expand their holdings in order to continue operating at acceptable profit levels. Those who want to expand anticipate trouble in acquiring more land because they believe the coal companies can offer more money for any acreage which becomes available. At the same time it is doubtful that any outsider interested in buying land for farming or ranching would do so in this area, knowing of the press for coal development and the ramifications such industry brings. Hence, ranchers feel a squeeze at both ends: they cannot reasonably expect to acquire more land for their own needs (and a replacement ranch is very difficult to find), nor can they expect another rancher or farmer to buy from them in light of the coal competition./32 On the other hand, as noted, others want to sell or lease to the coal companies. Lack of accord on whether or not to sell or lease has created a strain within some kinship groups, but no such discord or division has been observed by the researchers between ranchers and their wives.

Most ranchers feel that while they might be able to get along with strip mining activities, they cannot accommodate mine-mouth electric power generating plants, gasification plants, and the like. These appear to be destructive to ranching because they bring many additional people. Some are saying they can live with what has transpired to date and possibly with further energy development activities, but they want to see the impacts of Colstrip's first two plants before trying to take on more. Being cautious about social change, they want time to adjust to the current situation before further change occurs. Others resist even the start of mining, fearing that "one thing will lead to another." These persons believe they are faced with an all-or-nothing proposition. Where one draws the line with respect to how much development he can tolerate depends upon his own ability to imagine an acceptable scope and rate of industrial growth and to recognize the social, personal, and resource requirements entailed.

Aside from the personal and social effects being acknowledged, there is a great deal of concern about the water needs and supply in the coal areas. Ranchers interviewed expressed fear that the rivers will be "sucked dry" (dewatered) /33 and that potable ground water will become contaminated through mixing with surface water (often not potable). Some expressed the concern that, if mining disturbs the natural flow of ground water, meadows will dry up as springs disappear. Construction of power transmission lines and aqueducts also may disturb the springs. The power companies' offers to drill wells for those whose springs do go dry is not satisfactory, since wells are difficult and costly to keep up, they do not water meadows, and they are not as dependable a water source as springs since the latter do not freeze. Interviewees emphasized that, while the law provides money for damaged water supplies, a payment is a totally inadequate substitution for such a vital life source.

Even if water sources go undisturbed by coal mining, many ranchers feel the water and air may become so polluted by the proposed power plants that cattle raising will be jeopardized. Further, the success of reclamation efforts has yet to be domonstrated to the satisfaction of most. A company's announcement that only a small amount of acreage will be disturbed is misleading in that the disturbance can divide a ranch, whether it is due to mining itself or to the installation of power lines or rail spurs. Also, the portion of land to be disturbed could be located over a spring. Ranchers cannot control such aspects of coal development and therefore have little or no incentive to improve their operations because they have little or no assurance of any return on increased investments. On the other hand, failure to improve and expand ranching operations is synonymous with failure to be competitive. If they knew that development would go only so far and no further, ranchers could make certain commitments and take certain stands. As it is, much of their information is based on rumors rather than on confirmed or official statements.

The many rumors prevalent contribute to the pervasive sense of uncertainty in the area and make life difficult to enjoy. The rumor that pollution abatement equipment will not work as well as expected has created a special worry for ranchers, most of whom do not have a clear understanding of the operation of scrubbers and the like. In addition, power officials say they are not sure just how much pollution there will be. Those downwind of the plants worry about the harm their cattle may sustain through exposure to an unknown quantity of contaminants. The uncertainty of utmost concern is the undetermined number of people coming into the area; and "people pollution" is feared more than ground, water, or air contamination. Newspaper announcements often feed and substantiate some rumors; others are hard to check out. These uncertainties make all planning difficult, whether it concerns expanding one's ranch or business, constructing additional housing, or accommodating a large influx of school-children./34

b. Discussion

Rumors about development and coal developers are rife throughout the study area, an unsurprising occurrence when great interest, concern, and anxiety are coupled with a continuing lack of reliable and trustworty information on the matters in question. The anxiety breeds rumors, which create further anxiety, and so on. In this kind of situation, paranoid-like reactions appear to be inevidtable. The more threatened one feels, the more one tends to become suspicious and to feel at least socially abused. It is not uncommon for ranchers who oppose coal development to feel that they are part of a persecuted minority group in the United States.

Landowners are being made constantly aware of their vulnerabilities and lack of power in dealing with social interventions from the outside world. Until recently, landowners felt in control of their destiny. This feeling is rapidly disappearing, even though ranchers continue to be able to handle normal, recurring stresses well--and to do so collectively as well as individually.

Most ranchers are acting in opposition to coal development and tend to engage in conflict relationships with the coal industrialists, their representatives, and their advocates. Their ties to the land are strong, and a desire to hold their land in trust for future generations is fairly prevalent. The ranching unit is necessary for the way of life desired by most ranchers interviewed, some of whom would not be at all satisfied with a lot of money and/or a big ranch in place of what they currently have. They feel that they are "somebody" (i.e., that they can enjoy a certain desired social status) only if they can remain where they are.

Southeastern Montana is a good example of a place whose residents share a culture yet do not constitute a society. The area is actually made up of many small societies; some of these "natural communities" have formed in the face of the coal issue.

The labels "pro-development" and "anti-development" indicate only one's preferences, not necessarily how one would react either to offers to use one's land for coal development or to coal-related events which one expects will affect one's land and life-style. The correlation between attitudes and actions is always uncertain. Some ranchers who have tried unsatisfactorily to accommodate coal development and who still tend to favor some form of it are now actively fighting it. Some who oppose it are hedging against an uncertain future by acting accommodatively toward development, for example, by leasing to land developers.

Some of the considerable complaining about MPC is probably normative and is only intensified by recent industrial events. Like other industrial giants in the state, MPC is viewed with a mixture of admiration and fear. Certainly the company and its subsidiary which runs Colstrip (Western Energy Company) have a side to the story of events about which complaints are being voiced. Some (and perhaps most) of the employees in coal-related jobs are doubtless doing their work conscientiously, expertly, and humanely. However, some who work for MPC are comparatively less considerate of the feelings and wishes of the locals and consequently are instrumental in creating negative images of the company. In addition, some of the negative impression of MPC comes more from its objectives than from the actions of its field staff. Thus, what the company is constructing at Colstrip is in and of itself having a massive negative impact on southeastern Montana.

Likewise, Western Energy's policy of owning Colstrip is making some newcomers feel that they are at the mercy of those who are planning and running the town. These newcomers want more voice in managing the affairs of the community; they want it to be modeled more after a participatory democracy than a fiefdom.

There is a particular irony in the feeling among the WASP-like (white, anglo-saxon, protestant), anti-development ranchers that they are rapdily becoming a persecuted minority in the wake of coal development. For years they have been considered prototypical rural Americans, the backbone of the country. Now, suddenly, they are being accused of standing in the way of "progress" (i.e., industrialization of their area). They are in the process of undergoing a radical change in status which they find both befuddling and outrageous.

Most (and probably all) ranchers are having a very difficult time imagining the future, which is usually largely a matter of extrapolating the past and present as part of predicting where perceived trends are going. It should be borne in mind that people problems are much more common in ranchers' experiences than other problems associated with coal development. Indeed, such possible problems as air pollution are still considered abstractions for they are simply outside the ranchers' past experience.

The prevailing situation, for ranchers as well as for townspeople and newcomers, tends to generate scapegoating behavior. Rightly or wrongly, scapegoating of MPC, Western Energy, the county commissioners, and other likely targets abounds.

2. The Reactions of Townspeople

a. Townspeople in the Study Area

There is a good deal of suspicion among the inhabitants of Rosebud County that much of the tax money generated by coal development will be used by the more populous areas of the state. According to one interviewee, this is no longer a suspicion.

> The percent of net proceeds tax paid the county has been reduced, with the balance going into the state general fund. Property taxes are paid and then redistributed on the basis of population for equalized school foundation funding. Consequently, no so-called "impact" money is made available to the affected counties.

Some even think that the larger cities of Montana are pushing for coal development in order to get more tax money — a dollar benefit for which eastern Montana would pay a high social cost. One resident stated:

> This suspicion is substantiated by the fact that a reduction to the county's share of the net proceeds tax was passed by the legislature, last year, and that $136,000 was taken out of the Rosebud County school funds to finance education in Montana's urban communities.

People in this part of the state feel that many other Montanans would like to joint out-of-staters in taking advantage of the area.

Many stated that the coal companies were not being taxed enough or were evading responsible action./35 One informant commented:

> Traditionally, legislation in Montana has been written for the benefit of large ventures. This same tradition is still evident in the state's tax structure.

Whether or not sufficient tax money from coal will flow into the county, at least some locals are already enjoying substantial economic benefits.

The Forsyth residents interviewed showed considerable reluctance to examine the nature of their good economic fortune; this reluctance is affecting their ability to plan ahead. Several reported perceiving a pervasive sense of greed in the community and a concerted effort on the part of coal and power companies to play up to the latent greediness in some businessmen and landowners. Some in Forsyth who originally completely welcomed economic development are now beginning to complain of such attendant social costs as a continually overcrowded downtown area. Also, a feeling of fatalism about the future was reported cynically by some area locals because of their view of the power of the big companies, and resignedly by others because "you can't stop progress." For the most part it appears that, whether their current concerns and interests are primarily economic or not, residents are very much oriented to the present, although the ranchers have more interest in preserving the past than do the townspeople because they are more concerned about the possible long-range adverse effects from coal development which could put them out of business.

Few townspeople in Forsyth are upset about development in regard to both what has already happened and what is anticipated. They feel it will benefit most people. One individual who agreed with this view stated that the life-styles of people in Forsyth had not been significantly affected. According to her, people who have been here a long time "feel they have a priority on the place but that will go by the board before long." Another stated:

> Most of us would not want our way of life to change very much. If there is a large expansion, it could seriously affect us. The effect so far is not very great.

However, one informant did not like the idea that the local women were being exposed to "foul talk and dirty people who are very noticeable in the bars now"; most local men would agree that the women should be treated as ladies, in or out of taverns.

Commenting on the population influx so far, one townsperson stated that it "has been gradual enough so that it hasn't hit us very hard." However, Forsythians are aware of being urbanized. For example, one said that he used to know everybody within a 100-mile radius but now knows only about 30% of the people in the area. Many of these new people anticipate being in Forsyth for an extended period. Until additional permanent housing is available at Colstrip, many employees whose jobs are expected to continue for some time will likely choose to settle in Forsyth; as such, they are believed to make potentially better citizens than the more temporary newcomers, most of whom have been and will continue to be at Colstrip.

With more housing going up at the construction site, builders in Forsyth are naturally hesitant to engage in what they fear may turn out to be an over-investment in the housing market. It is difficult to anticipate needs of this kind for more than two or three years ahead, by which time present construction activities on Colstrip's Units 1 and 2 will be over and a decision will have been made regarding the construction of Units 3 and 4. Approval would signal an additional three or four years of economic activity at Forsyth at approximately the present level, but the reaction to uninterrupted development is no longer generally favorable. The businessmen, for example, have indicated a growing desire to have a pause after Units 1 and 2 are constructed so that their impacts can be absorbed and assessed and in order to better determine what additional construction would mean./36 One expressed the fear, "Where will development stop?". He also added, "Montana Power needs to be open with people about its plans."

Most agree that development seems to have resulted in more money being in circulation now, and the quality of life for townspeople has not become noticeably different. Sympathy for the ranchers' plight was expressed, with interviewees noting that the cost of labor, equipment, and supplies for farms and ranches has risen sharply, putting pressure on landowners who need to expand in order to survive. One middle-aged businessman, a lifelong resident of the area, emphasized that landowners were not as interested in the money they could get from coal as they were in keeping their land and hence their life-syle. While land shortages are affecting ranchers and town residents alike, the latter (excluding newcomers) are not nearly so concerned with this aspect of development as they are with the pressures being brought on the schools, the sewer system, and especially the city water supply.

Until the city council moved to deal with the community's water problem in mid-1974, Forsyth residents were more worried about their city water system than about any other immediate community problem associated with the coal situation. People in town are reportedly still planning to drill more wells in an effort to supplement the inadequate local supply of water available from an outdated system. They evidently believe that the town will have a modern water system only after the present one is replaced. Some resent the possibility of a new system, since it is needed largely for the sake of newcomers who, according to one interviewee, "...will not be here long enough to pay for it."

The new residents in Colstrip appear to be much less settled than are their Forsyth counterparts. Some persons leave town because of boredom./37 "You can't even find a place to keep a horse." Many single and married men have chosen to commute from Forsyth, where there at least is a bowling alley and a movie theater. Some of the new workers find no job security and could be laid off at any time. Out-of-state people feel they have lower priority in this regard than in-state workers. However, the pay scale and working conditions on these jobs are considered "pretty good for the most part." Other immediate concerns, such as getting groceries, are changing as desired stores and facilities are constructed. Newcomers are quite concerned with the educational opportunities available locally, and several indicated a desire for a more varied school program. "If school people think of you as temporary, they won't be willing to put themselves out for you."

Other persons are attracted by life in Colstrip. Several interviewed said they liked the town's small size, although one teacher indicated that the move took some adjusting: "It took us a while to learn to shop by the month and not by the day when we moved to Colstrip." One newcomer from Billings, a mother of three young children, commented, "Living here brings a family closer together because you aren't always running off to K-Mart." She and her husband would prefer to live on a small piece of land and to own their home rather than be in town, but she "put an ad for land in the paper like everyone else does when they come" and got no response. They like working for a small company that cares about its employees. Another newcomer disagreed with them.

> They [the company] just walk all over the little man, and we are just white slaves is all. The money is great, but they take it all away from you [through the high cost sustained in living in a one-company job site].

This person's husband, however, pointed out the good wages ($13,000 to $14,000 per year for skilled labor), strong unions, and free weekends as some of the attractive features of working in Colstrip.

The housing situation is not one of these features. One rancher who recently talked with residents from each of Colstrip's residential areas observed that the enforced social stratification was resented and that strong animosity concerning it was already building in the community. Trailer residents confirmed this observation, with some feeling "labeled" and looked down on because they lived in the temporary area. The class segregation and residential selection process have reportedly created more social strife than they have prevented. Company spokesmen disagree with these observations and interpretations. One stated:

> We do not have an executive neighborhood. The distribution of population is based primarily on the date on which new residents arrive. Houses are being constructed continually and as they are completed they are occupied. It is not the intent of Montana Power or Western Energy to segregate the population according to job titles or work performed. The only division made is that many temporary construction workers live in trailers near the power plant project./38

Newcomers and local townspeople were also asked about their views of their ranch neighbors. One local housewife in Colstrip responded by saying that she considered the ranchers a complaining lot: they complain about increased taxes but "mainly because they don't own coal." This interviewee cited what she believed to be good progress made by those seeking to reclaim stripped land, indicating that she does not share ranchers' concern about the success of reclamation efforts. Because of her husband's good association with MPC and the fact that her parents were ranchers in central Montana, one of the newcomers felt that she was in a position to see both sides of the coal issue.

> But the ranchers here don't tell both sides. You'd think MPC was stealing their land when they're really getting a lot of money for it...I know from my work experience around the state that there are ranches for sale that they can buy.

Locals in Forsyth were much more sympathetic with the problems landowners reported.

Other interviewees felt that the ranchers were not really adversely affected by coal-related activities and cited examples. One Billings lawyer working with leases said:

> I've never seen a landowner yet that didn't have another ranch in mind if he can just get money for the one he's on. That's typical.
>
> Ranchers are as happy as can be to let you drill [exploratory] on their land because you agree to let them case the water for wells..We give them fifty dollars a hole and the right to case the water, and they're happy with that arrangement.

He also acknowledged some of the difficulties for both landowners and himself.

> Landowners just have to decide whether they can ranch along with mining. If they say they can't, I just go right on down the road and don't bother them...With oil and gas leases you can sign up fifteen a day, but with coal leases you have to live with them. We learned the hard way at Sarpy Creek—don't buy coal leases until you have the surface. In Powder River we have to buy the surface leases first, then wait as long as two years for federal leases and then anybody can go in and bid on it.

His views of the land vary.

> I have a ranch and I ran some miners off. I don't want them spoiling my beautiful place. I won't lease for even oil and gas exploration for fear they'll find something. But that's different because that is beautiful land, more desirable than this land we're talking about.

Lawyer's attempts to file for reservoir sites, which involved threatening landowners with condemnation, were reportedly made only because the state had failed in its duty to file for that water. They believe the three-year moratorium concerning water from the Yellowstone and its tributaries (See Chapter 2) may give Wyoming and North Dakota a chance to impound the water. Various interviewees agreed that Montana should be protected from water rights usurpation by North Dakota and Wyoming and that industry should pay for water development./39 The water rights question is bothering more and more people, including landowners north of the Yellowstone. Few would mind if the companies relied on storing spring run-off water but are not sure that such a source will be sufficient for anticipated industrial needs.

Interviewees stated that big companies want big coal reserves in order to increase the value of their stock on the market and to have a replacement for other fuel they are losing because of shortages. They are also interested in locating and obtaining the rights to low-sulfur coal. One prominent Billings land broker said, "In three years it [coal development activity] will be all over for us. The coal companies will be located by then." In other words, all leasing and land sales activity will be completed.

According to the land brokers interviewed, coal companies are having difficulty in dealing with landowners because the former cannot understand that offering more money will not automatically resolve all problems in negotiating for leases. The landowner's values must be determined and a lease written that takes these values into account. Because ranchers fear having to deal with a railroad, coal company, or the federal government, who are considered inaccessible if something goes wrong, land brokers are used as go-betweens. One stated, "We will stand in your [the rancher's] shoes, be a buffer, be responsible, be available." However, these interviewees are also concerned about one company's extended buying rather than leasing in the Decker-Birney area, wondering what will happen to an area where a big industry owns so much land. They report that a great deal of money is being offered to the ranchers here so that the coal company will be in a stronger position to negotiate with a large ranching business that borders these ranches.

In spite of their expressed concern for the landowners, the land brokers stated that they had sold the companies on their singular ability to package coal-rich land into economically attractive, strip-mineable units and were capitalizing on the companies' need for people who understood both the legal aspects of coal development and the uncertainties felt by area residents. They indicated that they did considerable lobbying at both the state and federal level to try to influence policy and that, if the federal government would establish a leasing policy, it would minimize the economic pressures and gambles for everyone. Various policies were cited as being needed and concerned: whether or not to allow mining without the landowner's permission; whether or not legal title to surface rights is needed or just a bond for anticipated damage; when federal coal will be leased; and whether or not the government can or will restrict development of power generating complexes, gasification plants and other industry.

The people pollution problem which would be created by mine-mouth generating plants has prompted interviewees in this group to feel that it is more desirable to process the coal elsewhere than locally. Even the present activity has not been wholeheartedly received for this reason./40 These townspeople would prefer that industrialization be kept on a relatively small scale even though, like construction workers, they are subject to irregular layoffs when coal contracts begin and end. Their salaries are good, with many drawing overtime pay. As a group, they generally believe mined land can be reclaimed, although some are cynical about the claims made by the companies.

The reclamation issue notwithstanding, one county official believes it is the landowners who have nothing to sell that dislike the industrialists. This person has little sympathy for the landowners and thinks they are overly possessive of their property. He also feels that the quality of newcomers, overall, has been good. Few complaints have been formally voiced to Rosebud County officials about MPC but the possibility of condemning land for transmission lines rights-of-way and reservoirs has added to an insecurity and uncertainty which bother most people in the study area, including Indians.

Except for the sections in the northeastern part of the reservation which are owned by the Burlington Northern railroad, the Northern Cheyenne tribe owns all the mineral rights to coal on its reservation. Three Indian interviewees observed that Indian landowners feel they are not adequately represented on the tribal council, and the Northern Cheyenne Landowners' Association was organized to look after surface owners' interests. When Indian ranchers here disagree on coal, their interpersonal problem is great because they are much closer to each other both physically and socially than are ranchers in the adjoining Decker-Birney area. The traditionalists are against tearing up the ground, and it is the younger and older tribal members who tend to be in this group. The more acculturated Cheyennes tend to favor development. Some feel they should mine the coal themselves. Those who would say, "Let's let them mine the coal," are not vocal and reportedly are probably in the minority. Speaking for many, one said resignedly that mining would be done here despite the general feelings against it because the external pressures to mine were enormous--"So what's the use of fighting it?"

Some recognize that what happens in the Decker-Birney area will affect the reservation and that what happens on the reservation will likewise affect the surrounding area. Two persons indicated that the tribal council should modernize and that the tribal government needs to become more functional and responsive to the needs of the people, especially now that industrialization seems imminent. Because everyone is related and there are so many political factions on the reservation, these interviewees felt that the very process of doing social impact research here would probably do more harm than good. However, the tribal officials contacted believe it is likely that the tribe will soon have to intensify its efforts to obtain needed social impact data.

2. Discussion

Some construction workers, visiting bureaucrats, newspapermen, and others who are passing through Colstrip consider the locals "natives" and make no serious effort to know them or be known by them other than categorically. In these and in other respects they act like tourists rather than seriously attempting to understand or adopt the locals' culture. "Boomers" (i.e., transient construction workers) are the extreme case, except that they are more contemptuous of locals than actual tourists are apt to be. It is not surprising, therefore, that Forsyth's locals are inclined to view new residents (most of whom work at Colstrip) as transients. The locals are presently disposed to continue established roles, relationships, and activities and to avoid exploring friendships with newcomers./41

Regarding development itself, Forsyth's locals are not having second thoughts about coal-related industrialization, but "minor annoyances" are beginning to be perceived by some Forsythians as more than they anticipated. Merchants in particular have started to question the desirability of continued development./42 Townspeople are quite aware of the landowners' plight and are more in sympathy with ranchers than most of the latter realize.

As for the newcomers at Colstrip, the husband's job is put first, and it is the main independent variable in their lives. Only in this sense are they not family oriented. Many feel that their families are closer than ever before because there is so little for them to do but associate with each other./43 They have few opportunities to do what they really want, despite the various offerings provided by the several voluntary associations which have formed. As a result, going for one's mail is still a big daily event at Colstrip.

Newcomers and temporary residents have particular problems. The lack of a sense of community among them has impeded their developing a good communication network, which in turn would help foster a sense of belonging. Also, it is difficult for them to put down social roots even when they so desire, when, for example, they are labeled as transients by being put in a temporary trailer area. Locals also keep newcomers socially distant, perpetuating the latters' feeling that they are and will continue to be in but not of the local scene. After a couple of years, miners and their wives who really work at it can begin to gain acceptance as locals. It remains to be seen whether construction personnel who are at Colstrip that long or longer and who work at putting down social roots will be able to achieve a similar status.

Newcomers, socially so remote from the locals, frequently have little or no idea of how they or the work they are doing (e.g., building an electric power plant) affects the permanent residents of the area. Also, newcomers who are temporarily working at Colstrip tend to feel morally unconcerned about the possible effects.

At the other extreme are construction workers who are former farmers or ranchers or their sons who had to find other work because the business failed or had no place for them. It is evident that some of these workers are keenly aware of their impact on rural locals. Around Colstrip, for example, most rural locals are the survivors of years of gradual expansion of ranches often made possible because smaller ranchers (like these construction workers or their fathers) could not succed. These construction workers appear to be jealous of the continuing ability of the bigger ranch operators to survive and indeed flourish. One can easily sense that these workers are quite aware of the impact of coal development on the big ranchers around Colstrip and would take a certain pleasure in seeing the successful ranchers "get it" from industry just as they or their fathers "got it" from the bigger ranchers years ago. As one worker observed, "The little ones got gobbled up by the big ones and now the big ones are getting gobbled up by the big ones big ones and now the big ones are getting gobbled up by the bigger ones. Life's like that."

Like environmentalists, strongly anti-development ranchers are called radicals. These ranchers are actually traditionalists and/or conservationists who want to maintain the status quo or to return to the status quo ante. It is perhaps because the so-called radicals dare to try to do what others view as standing in the way of progress that the others perceive them as "radicals," people who are trying to interfere with the "natural evolution of things," which happens to coincide with what the others want to take place.

One way to view the general impact of development is through the concept of impact gradients. For example, if one draws a series of concentric circles around Colstrip until Billings is included, one can graphically show that the zone around Colstrip is receiving the greatest social impact from MPC power plant construction, the zone around Forsyth (36 miles away) the next greatest impact, the zone around Miles City (about 80 miles away) still less impact, and the zone around Billings (about 125 miles away) the least impact. (Billings is making money, to be sure, but other coal-related impact on the city is negligible). This scheme applies only to towns; impact on the rural areas which have coal is great and widespread. Throughout the study area, however, there is a general feeling of inevitability concerning the industrialization of coal resources.

Places like Forsyth are unprepared to deal with rapid and widespread growth. They need help per se, and they need help in learning how to assess their needs and meet them. The question remains, what are/should be the responsibilities of government and industry in providing such help?

3. Social Effects and Other Changes Attributed To Industrial Developments

a. Social Effects and the Social Structure

The social effects occurring as a result of coal development are particularly visible in the schools, with unprecedented pressures being felt at Colstrip./44 The former (reportedly non--racial) rivalry between Indian and white children at Colstrip's school is now giving way to a coalition of these two groups against the children of the newcomers working in coal-related jobs, who now greatly outnumber the locals. On the other hand, one teacher observed that the local students were not noticeably affected by the new ones and that life seemed to be going on as before. An administrator felt that the newcomers mixed in quite well with the others. The split classes deemed necessary to reduce class size have separated friends of long-standing, and until recently there was fear that a split shift would be required. This would emphasize the local-newcomer gap still further, with the children of farmers and ranchers riding the bus together to school for instruction during one part of the day and the children of the construction workers and miners walking together for classes during the other. The new school hours would have created hardships for many and given some children too much time with not enough to do./45 Some of the established residents are discouraging their youngsters from associating with the sons and daughters of newcomers any more than is necessary, and in the views of parents and teachers local girls who date construction boys often find that their old friends distastefully regard them as fraternizing with the out-group. It was hypothesized that the differences which are becoming increasingly evident at school will bring out similar differences in the parents or in the community, with the younger generation more able to adjust to the strains created and more accepting of change and new friends of various social strata./20

The pride once felt about the Colstrip school, which has been the focal point and center of activity in this community, and about its tradition of quality is wanning as newcomers come and go. Locals fear that the overcrowding and the athletically (more than academically) oriented children of the newcomers are affecting, i.e., lowering, the quality of education offered. Teachers' relationships with students are reportedly not as satisfactory as they were when classes were smaller. The assumptions and values of the locals are being questioned by the newcomers, and teachers share the sense of uncertainty and insecurity felt by the ranchers' children. School personnel are faced with the "impossible" task of trying to predict just how rapid school growth will be./47 Some ranchers fear that they will be voted off the school board and that the newcomers will then increase the bonded indebtedness, which the ranchers and other landowners would have to pay. (The last school election, however, did not change the proportion of ranchers on the school board.) Further, newcomers who are not yet paying taxes to help support the school system have made various demands on its facilities for recreational and religious instructional purposes, and there requests have both puzzled and annoyed the locals.

For the most part, Colstrip High School still offers little aside from a college preparatory course, although the planned addition will make it possible to expand language instruction and to add shop instruction and adult education. One teacher pointed out that it was hard for new students to adjust to a new school program and that most of them just coasted along, knowing they would not be there very long. Many of the students have been so transient that they have never participated in sports or other extracurricular activities. Students from town, especially newcomers, have a great deal of time on their hands since they have apparently little homework, no farm or ranch chores demanding attention, and no opportunity for part-time employment. With the exception of involvement in group activities such as Scouts, 4-H, Rainbow, Teen Club, or Little League, which parents help chaperone, there is very little for young people to do in town and few places for them to go. (In this respect their situation is similar to that of many construction workers' wives.)

Forsyth has approximately twice the number of schoolchildren as does Colstrip. The community has three school buildings, one each for the elementary, junior high, and high school grades. Classes are larger than before development, and a shortage of teachers and supplies was noted./48 One teacher reported perceiving no major problems between new and old students. Another stated that the transient children were "more aware and worldly" and that it was more a matter of "cowboys versus longhairs" than old versus new. New students reported that it was easy to make friends but that there was little to do in town except bowl or go to a movie. A high school sophomore, whose parents were locals, stated that she did not find the newcomers particularly noticeable. One teacher observed that the new students were not inclined to apply themselves, knowing they would be changing schools before long, and an administrator said that the high schoolers were taking advantage of new teachers and presenting a discipline problem in many cases./49

No drug crisis in either Forsyth or Colstrip is evident to date, although some parents have expressed more concern about this possibility than about the use of alcohol, which knowledgeable interviewers believe is far more prevalent than drug abuse. Teachers in both towns noted that more marijuana was being smoked, but probably considerably less proportionately than in the bigger schools of the state. Both teachers and students report that there are generally more drugs available now and that usage has become more of a problem. Further study will be necessary before the actual dimensions of alcohol and drug use can be specified. Meanwhile, there is a growing concern about the apparently increasing tendency of youngsters to experiment with marijuana along with alcohol.

Although the incidence of county-wide illegal drug usage has been minor so far, the number of assaults in Forsyth and in the county as a whole has grown significantly. One well-informed officer estimated as many as 50% more arrests, with many disturbances reported. A city official noted an increase not only in the number of brawls in local bars but also in the number of domestic problems and child custody cases, although these incidents have not been as numerous as had been anticipated. While legal problems in Colstrip have not yet generated much business for private law offices, violations of the law, such as disturbing the peace, have become increasingly common. The population influx has been accompanied by an undesirable element, which is widely considered to be involved in (if not the source of) most disturbances, and the sheriff's staff has had to expand in the interest of maintaining order.

Social effects are also being revealed through the churches in the study area. The various denominations in Forsyth have grown substantially. A similar increase has also occurred in Lame Deer, a small community south of Colstrip. The two churches in Colstrip (one nondenominational, the other Roman Catholic) did not grow significantly until this spring, and a Lutheran church is being built. While the significance of the specific seeking and selection of preferred religious affiliations requires further study, the newcomers' "class consciousness" has become visible through their definite church preferences. For example, most of Colstrip's Protestant newcomers who are churchgoers evidently would rather travel a considerable distance to attend the church of their choice—which is apt to be associated with a particular stratum (Demerath 1965, p. 2)—than to participate in the nondenomination services available locally. Overt and obvious social stratification is new to Colstrip, where the tendency has been to gloss over and minimize social differences within the established structure./50

Because most of the pre-boom citizens of Forsyth are long-term residents and many are related to each other, their existing social system, composed exclusively of long-term neighbors, friends, and relatives, is well established and not structured to recruit new members. Semiformal groups are of long standing in this established trade center, and social activities often cut across generational lines. When coal development began, there was an intensification of existing relationships in an effort to keep one's distance from what was happening and from the newcomers. Locals, while curious about the newcomers, were not especially eager to meet them or to mix with them socially—and vice versa—because of their differing interests and values.

The social impact created by coal development and the influx of newcomers is variously affecting different groups of locals. Housewives in Forsyth find that shopping is less pleasurable now because the stores are more crowded and there are so many unfamiliar faces. However, they also acknowledge that newcomers are bringing more money into the community, and in many instances their husbands are now earning more. Newcomers are not threatening to integrate established neighborhoods because mobile homes, the only residences available to newcomers, are generally confined to the outskirts of town. Thus, for local housewives in Forsyth, coal is not a big topic of concern; it is neither drastically nor directly adversely affecting their lives or lifestyles. A Colstrip counterpart summed it up by saying, "Life is pretty much as it has been—same old friends (and social circles)."

As far as the merchants are concerned, coal development has enlivened the town. Business is good, and they are doing well whereas they formerly managed to "get by. They have become conscious of their stores' images and are thinking of expanding. Many are reluctant to expand or to carry much more inventory, feeling that the present boom will last only as long as the construction at Colstrip. As such, coal development has not created much of a change in their lives, other than that they are busier and working harder. It admittedly has made labor more expensive, but, with income substantially up, there really is no problem in meeting this increased cost. Coal development has not been a big issue for this group.

Merchants have also become more aware of their real source of income (the landowners) and are trying to improve strained relationships with these customers, who might choose to do business with new stores after the construction period is over and thus abandon the established stores. There is a growing reluctance to be dependent on a large, temporary labor force, and the recent several-week strike at Colstrip has intensified merchants' awareness of the problems they could be facing as a result of more industrial activity.

People on fixed incomes—the aged (given its size, there are many single, retired men in Forsyth), local government employees, and those whose salaries are not rising fast enough to keep up with the increasing costs of goods and services—are suffering from the economic boom. Also, those wishing to retire from ranching cannot do so in Forsyth because there simply is no place for them to live. How many there are in these categories and how many have had to leave town because they could no longer "make ends meet" are areas for further research, but the number involved is generally believed to be relatively small. Coal development has certainly had an unpleasant economic impact on these groups and is already threatening to socially uproot a few people, but locals feel that so far the life-styles of these persons have not been significantly affected./51

With the exception of the office of the sheriff, almost all offices housed in the county courthouse and city hall find that coal development has not really changed the pace of work, although one city official said that it was taking a lot of his time and was requiring him to add more staff. For the most part the services these departments and agencies offer have not felt any great pressures related to development. For example, the number of welfare cases has not increased in Forsyth./52

A critical problem faces the medical services organizations, however, which have always been understaffed. The two physicians and one dentist who have been in town for years have not been able to handle the increased caseload, but the addition of a third general practitioner (who just arrived in May of this year) will help ease the pressure. It was reported that a big increase has occurred in the number of cases of venereal disease and that many of the new schoolchildren lack immunization records, complicating health care. Health care personnel are overly busy to the point of being harried and have had considerable difficulty recruiting needed additional colleagues. One lawyer, however, stated that law practice in town had not increased much. A shortage of other kinds of skilled personnel, such as plumbers, was also noted as a consequence of growth. Coal development is thus affecting these groups of interviewees in different ways.

While locals and newcomers meet at church, the bowling alley, the movie theater, and in offices and stores, it was reported that they do not mix very much socially because of their differing interests, commitments, and values. Some do go to the country club, play bridge with locals, and attend square dances, but for the most part these activities are not widespread among newcomers. Miners who have been in town for two or three years and expect to remain have adopted the local values. These newcomers are an exception and have been accepted by the established residents./53 Local railroad workers view coal development favorably because it has also brought them the promise of job security, and it is likely that the younger railroaders with little seniority will experience few layoffs in the foreseeable future.

Construction workers are not likely to have such futures, however. There are, in one sense, two different kinds of construction workers at Colstrip: those sent by their unions, and those who freely chose to go (career itinerants). The latter are neither boomers nor local workers (persons whose home is Billings or a small town in the area). Construction employees fall into several groups, but insufficient data have been gathered to date to permit a discussion of the various types represented. Some workers come with their families; others do not. Those whose homes are in towns reasonably close to the construction site generally leave their families behind.

With the exception of Colstrip's new "core residents," who, knowing that they will be here for an extended period, are putting down roots and socializing more among themselves, social life for the most part is characterized by frustration and boredom. Those used to being outside or making or repairing things at home find themselves cramped by trailer court life, which is expensive /54 and affords little space or privacy. With few gardens to tend (gardening has been limited because of the water it requires), no property to improve, no outdoor work to occupy one's time, and no downtown to visit, Colstrip's trailer occupants find they are reading or watching television more than before. There is very little neighboring in the temporary trailer area where most workers live; there is more neighboring in all areas across the tracks, where the atmosphere is more one of permanence or at least less one of a work camp. Some in the work camp area may not want to make friends, given the short time they expect to be here, and since it is hard to make and break friendships these newcomers for the most part stay socially distant./55

Most residents leave town on weekends, driving to Forsyth, Miles City, or Billings to shop, take in a movie, have dinner out, or otherwise take advantage of the city offerings so many miss.

> A lot of people . . . really like
> to go to Billings or Miles to
> shop and get haircuts and the
> like in order to get away from
> here for a day.

Some interviewees pointed out, however, that these needs and desires to get away had the effect of making Colstrip an expensive place to live.

b. Changes Brought by Coal Development

Coal development has wrought a great many changes in the study communities in eastern Montana. In particular, changing relationships and views of ranch friends are evident. It is difficult to discuss the coal issue frankly, trustingly, and uninhibitedly with those who hold opposing views, positions, or commitments concerning development. For some, to even ask another's view is considered an intrusion on privacy, given the Western tradition of individual independence in personal and business matters, and many simply avoid the topic. The researchers have observed that often each of the friends will make some erroneous assumptions about how the other thinks, feels, and acts on the coal question and will note that the position he holds is not treated fairly in news reports or public forums. As coal-related matters grow more difficult to discuss with friends presumed to hold opposing views, relationships tend to become increasingly strained with the continued avoidance of an issue of such paramount and mutual importance./56 At this point interaction in the relationship becomes very self-conscious.

It should be noted, however, that it has recently become easier to discuss the coal issue, after those concerned began to realize that avoiding such discussion with neighbors left everyone feeling emotionally isolated and politically powerless. The collectively perceived need to unite is beginning to supplant the collective inclination to face it alone.

Other aspects of change are apparent. A shift in power from the ranchers to the new mining industrialists is very evident. Ranchers interviewed noted that their favored position of the past was being altered and resented their loss of status; others reported feeling that the ranchers had enjoyed too much status. In particular, ranchers in the past enjoyed voting power, prestige, and a good relationship with the county commissioners. Now the ranchers feel they hardly know their commissioners; the latter have seemingly withdrawn from their ranch constituents, and no longer do the two talk about the same things./57 Some ranchers noted that the commissioners no longer smiled because the pressures and strains accruing from coal-related developments had been "getting them down." Others interviewed indicated that they felt the county commissioners ought to be replaced with persons more capable of dealing with coal development, while still others expressed suspicions that the commissioners were being "hoodwinked" by MPC or were being unduly influenced by high level, pro-development state politicians. Ranchers feel a need to represent themselves actively now, not just through voting, but through organized efforts beyond their traditional, predominantly agrarian activities.

Regarding merchants, whom area ranchers have supported for years, interviewees note that the businessmen seem to be catering to the power and construction companies, apparently forgetting that they were once (and in large measure still are) very dependent on the ranchers. Because of their refusal to help fight coal development, the merchants are more or less resented by the ranchers, with some (to date a small number) going so far as to boycott business in Forsyth altogether. At the same time, however, many ranchers around Colstrip report that they are socializing with the new "coal elites"; they are finding that they have more in common with these newcomers than they do with local businessmen. Also, many merchants are now seeking to renew their friendships with area ranchers; for example, they have indicated an interest in meeting with the Rosebud Protective Association to see if the two groups can work together.

Energy development activities are also affecting ranching operations as well as established personal and business relationships. For example, it is difficult to find ranch help now and, as stated earlier, to maintain normal expansion of one's holdings. Also, many are discovering that less time and money are available for ranching because of the necessity of traveling to meetings related to caol development. Ranchers reported feeling a need to inform themselves of how to protect their intersts, such as water rights, and of how to protect themselves and their property in the wake of rapid industrialization. Time spent away from the ranch has a definite impact on its operation. More direct effects brought about by energy development were noted. An example is the construction of power lines, which brings difficulty in operating tractors and other equipment near the lines and the possibility of being shocked./58

In addition to these changes, various pressures have been created by coal development, including the need to quickly expand the schools, the lack of time to digest the consequences of present development before more is threatened, the need to make decisions before all the facts are known, the pressure on landowners brought by land brokers, and the financial strain created by suddenly and sharply rising taxes to pay for increases in educational and law enforcement costs. Landowners find themselves subsidizing coal development through a variety of increased taxes. Area locals in general resent the newcomers for this unwelcome burden, which has been imposed for various needs. Commenting on this complaint, one newcomer stated:

> The locals resent our not paying
> taxes. Well, they won't let us
> have any land to have a house on
> which to pay taxes!

Landowners see themselves paving the way for a population invasion composed of persons who will absorb them and eventually, in the words of one, "kill them."

The residents of Colstrip who have been there for several years or more are finding that the community is no longer theirs; it already belongs to others./59 This formerly quiet, peaceful town now constantly experiences the sound of motorcycles and other sources of noise foreign to the local scene. Locals here and at Forsyth are feeling socially uprooted and the loss of their former sense of community as the impact of newcomers becomes more apparent and as traditional networks of relationships undergo continual strain and rupture. Miners in particular voiced these feelings. As locals contemplate future changes of greater magnitude and at a faster rate, they become very anxious about being able to manage their lives satisfactorily. Factionalism related to the coal issue has added to the sense of being a stranger in one's own town./60

In Forsyth, signs of growing urbanization have contributed to the beginnings of feelings of alienation and to a slightly diminished sense of community. Having difficulty in finding a parking place; waiting longer in lines at stores and at the bank; being busier; paying much more for every good and service; realizing that local facilities, such as the water system, are inadequate to accommodate a large influx of residents; and having the feeling that it is necessary to lock up prized possessions such as one's home and car, whether living in town or in rural areas; all are related to rapid population growth. Some parents fear that it is now too dangerous for their offspring (or themselves) to go out walking at night, given the presence of many "young, lusty, and footloose construction workers" (respondent's description). Further, all but two of the bars in Forsyth have been "taken over" and, in the view of locals, become crowded and unsafe. They perceive that in most bars they now find themselves subjected to ridicule and the object of provoked fights, and some bar owners are beginning to forbid the "rougher elements" from coming into their establishments. Increasing numbers of local people are going to Forsyth's country club, "where we have good control of things." Feeling the need to lock up possessions, to keep one's daughters off the street at night, and to avoid favorite taverns are highly symbolic of how locals view the invasion of newcomers. As one informant put it, "Development always brings in a lot of riffraff." People in Forsyth do not yet feel that the social impact of development is great, but they are growing more aware of how it could easily become so.

In rural areas around Colstrip, the loss of sense of community has been accompanied by a loss of privacy which has been keenly felt in a number of ways. Ranchers note a continual invasion of private property by newcomers who wander through ranches, leaving gates open and who chase calves with their motorcycles or ride across fields, some of which have been cultivated. Congestion on local roads is repeatedly mentioned, along with the desire to avoid paving them./61 (Newcomers complain that the road between Colstrip and Forsyth is bad.) Many feel that the area is in danger of "Easternization," that is, of being subjected to all the urban problems associated with industry and overcrowding in the larger cities of the nation. Another term used was "Indianization," indicating that the local whites are now being treated in the general, subservient way in which the Indians have been and often still are treated.

As for the good associated with coal development, a more interesting social life was noted by several adventurous locals in Forsyth and Colstrip because there are new persons to meet and new friendships to make. Also, work opportunities have been provided for those who desire to get out of ranching, or who have already done so but wish to remain in the area, and for ranchers and ranch-hands who are looking for additional income. Several interviewed noted that the availability of work locally would encourage many of the young to stay. For rural people there is a certain excitement involved in opposing coal development. A great many ranch wives, most of whom are hearty, outgoing, and self-assured, have spent considerable time learning about the laws regulating coal extraction and water usage while the men have attended to ranching. Contact with national leaders and interest in the fight have added zest to these locals' lives, but this activity would be much more enjoyable if those against development thought they had a better chance to win.

c. Discussion

As a result of very evidently being on the wrong side of the tracks and being denied the many residential pleasantries and amenities which are routinely made available to more permanent residents of the town, the people who live in the large, temporary trailer area of Colstrip generally feel that they are being treated as social inferiors simply because they are (in the usual case) subprofessional workers on short-term assignment./62 In a sense, they are being made to feel looked down upon and ethnic even though they believe they are doing as much as any other category of residents to make possible the "progress" which coal development is alleged to bring about and contributing to solving the nation's energy problem.

One reason for the evident disappointment of many residents of Colstrip's temporary trailer area is that they expected relationships with fellow residents to be much more personal, and even intimate, than they are. It is especially frustrating to the many who have rural backgrounds; they feel caged because there is so little for them to do around the house. They are physically active, doer types who are uncomfortable in a living area such as the temporary trailer court.

Locals' life-styles are also being affected.

A noteworthy impact is the acute self-consciousness of the locals concerning many aspects of their lives about which there had long been unspoken, shared assumptions and other taken-for-granted norms. Changes in traditional relationships with merchants, criteria for socially stratifying people, the concept of one's place in the community, and indeed one's sense of community are examples of matters locals are feeling newly self-conscious about.

There is very little evidence that landowners are taking advantage of the opportunity to creatively deal with possible interactions between the familiar and the strange. Quite the contrary seems to be the case. The initial reaction to rapid and widespread social change is a peculiar kind of helplessness. While definitely able to describe and reflect on their situation, the ranchers have shown little ability to organize themselves to protect the individual and collective interests they can identify and explain. Apparently, the traditional readiness of rural neighbors to unite against destructive forces has been replaced by a modern rural inclination for the individual landowner not to get involved personally and directly until it becomes clear that no other course is available.

There is no doubt that traditional rural ties are weakening or disappearing from southeastern Montana. Reciprocity between neighbors, feeling morally accountable to neighbors, and the like are diminishing if not already things of the past. The coal crisis is bringing to the ranchers' awareness some of the underlying weaknesses and deficiencies in their community relationships, doubtless a significant factor in their present tendency to turn inward and react self-consciously to industrial interventions in their lives. Their growing realization of their vulnerability to these and related interventions is essentially a mass phenomenon: they are experiencing this realization largely as individuals who are not at all certain that their neighbors are experiencing anything like it. They are even uncertain about where some life-long neighbors stand on the coal issue, a clear indication that interaction with many neighbors is limited by a surprising reticence to discuss such mutual and fateful concerns. At the same time, however, ranchers in natural rural communities are beginning to once again establish associations and otherwise reestablish neighboring as a way of enriching their life-styles while seeking to safeguard them. This "back to gemeinschaft" tendency is so new that its probable effects on the established social system are not yet discernible.

The ranchers' social system is fragile because in a number of respects it is more nominal than real, more alive in the memory of what it used to be than in the actuality of the loose and uncertain social ties which form the basis for claiming that these landowners are members of a community. Although they continue to share a ranching way of life, they are doing so in smaller and smaller groups, much as urban dwellers share their particular way of life. The obvious great reluctance, perhaps inability, of ranchers to effectively band their small family groups together in the face of an enormous, commonly experienced threat to their way of life has the effect of making them "easy prey" to the industrial intruders.

The study area has been experiencing interventions in the form of urbanization for some time and has been changing in other, various respects. A big theme is change: the study area evidences rapid, widespread, uncertain, uncontrolled, multifarious (and often threatening) change. This change consists only partially of urbanization; it would be a mistake to assume that urbanization is presently the dominating change motif.

If serious efforts are to be made to help new and old residents manage their emerging situations, themselves, and each other, it would certainly be well to provide such help as teaching young wives of construction workers how to manage their domestic affairs in such isolated places as Colstrip and making available counseling and mental health services to the many old and new residents who are caught up in "future shock" impacts. More fundamental and enduring help will require giving both old and new residents more opportunity to have a significant voice in designing and implementing changes which affect their lives./64

4. A Question of Values

a. Ranchers' Values and Vulnerabilities

At present, land in the study area which has no strippable coal is less economically attractive than that which does. However, stripping does create some long-term problems. It entails a sacrifice of recreational values and of future land use possibilities, according to some interviewees. Many believe that the choice for coal development means there will be less food production both now and in the future, while others feel that some of the land may be more productive following mining and reclamation. Because stripping frequently does extensive damage to the land, concerned ranchers maintain that the cost of this kind of mining should be calculated in terms of the overall long-run effects created rather than solely in terms of the economic feasibility of surface as opposed to underground coal extraction techniques. When mineral rights agreements were originally signed, it was assumed that underground mining might be done some day. Many ranchers consider it unfair that this assumption is being ignored. They believe the nation should pay a realistically high price for the coal and should therefore deep mine it, not strip and destroy the land and violate the original agreement between ranchers and the federal government./65 Others, considerably fewer in number, view the land only as a means to earning a living; it has no intrinsic and enduring value for them. This group views the land primarily as a business item and is willing to risk its destruction and people pollution if the price is right.

Outsiders see the land as expendable, and dedicated ranchers sense that these people also look upon them as expendable and place a low value on the Western way of life. The ranch offers freedom, absence of regimentation, isolation, and quiet. Coal development threatens all these as well as the aesthetics of the area. Most of these ranchers feel that a demented value system is being imposed upon them and that their Western hospitality and trust are being violated. For example, newcomers do not have the same respect for the land as do the ranchers, who are more bewildered than angry about the abuses to which their property has already been subjected by the influx of trespassers. Many newcomers do not understand that a large tract of land is just as private as a fifty-foot lot and act as if these ranches are public property./66

Aside from having to deal with a great many new people who have foreign set of values, committed ranchers are beset by a number of other difficult aspects related to coal development--aspects which have put them in a very vulnerable position. First of all, neighboring ranchers are highly interdependent and together comprise a fragile social system which is in danger of collapsing if only one or two ranchers sell out. Commenting on the fragility of the situation, on interviewee flatly stated:

> That sums it all up . . . . We need each other in order to survive. Until this coal business entered our lives, we had been acting as though we were good neighbors but we had actually been drifting apart. Now we have to really be good neighbors again or we are going to be easy pickings for the coal people.

Another explained:

> Tearing up one's roots to allow rootless people in is not a solitary act. It has a big impact on one's neighbors, on their water, on their ability to live as they wish, and so on. How can anyone justify selling out to industrialists as anything but an antisocial act?

Some pro-development ranchers resent being made to feel that they should give up the money they could make from coal to preserve a neighbor's feelings, sensitivities, and way of life. Secondly, some who have leased land (primarily from federal and state agencies or the Burlington Northern railroad) are now finding that their leases are being taken away on short notice. When leases are withdrawn, competition for replacement land results./67 Ranchers are highly vulnerable, not only to changes in leasing policies and practices, but also to loss of water supply or its contamination and to the destruction of the highly nutritious, indigenous grasses by surface mining. Thirdly, their taxes are rising due to conditions beyond their control, and they fear a heavy tax burden when the coal boom is over. "We are paying for coal development," and "We are paying for our own destruction," were common observations. Fourthly, because as a group they are highly specialized in their work, deeply attached to the land, and committed to their way of life, ranchers find it difficult to adjust to the changes threatened by coal and related energy developments. They feel that they have no voice in the decisions which so fatefully affect them and that they are powerless to influence what is happening. They are uncertain about many aspects of what is going on and proposed./68

In the face of such ominous and sweeping change, it is obvious to interviewees that ranchers stand to lose everything they have and are. Ranchers realize that they are unprepared to adjust to coal development and hope that the more articulate among their members can do something to stop it. A few have emerged as natural leaders, taking it upon themselves to inform others and to represent them in matters of mutual concern. Some have become models of resistance to development and have revealed it as less than totally inevitable, but inadequate communication has kept many ranchers from realizing how much support they have for their views. Being outnumbered by both businessmen and construction workers, ranchers sense that they have the new status of a persecuted minority and are caught in what appears to be a losing battle: the nation's alleged need for coal versus the life-style of a few. Commenting on the general feeling that the industrialization of coal resources is inevitable, a Montana rancher said, "The very best that industrialization can offer is some extra money, which is too bad because, for people like me, land guarantees happiness, dollars don't." In effect, these ranchers are being made to feel guilty for trying to preserve their life-styles. /69

A commitment to a chosen life-style or to one's home ground which takes priority over the money which could be made by selling to coal companies is baffling to most industrialists, who cannot understand why anyone would forfeit a sizeable sum of money in order to maintain what to them has no particular personal value or appeal. Still, the values of most ranchers in Rosebud County incline them to want to accommodate coal company wishes. These efforts are continually rebuffed; ranchers encounter industrial values which are based upon conflict models of behavior and to which they do not subscribe. One interviewee summed up the situation by commenting, "Isn't that a terrible way to live, not to be able to trust anyone?"

b. The Price Paid by Workers

Established landowners are not the only ones who acknowledge paying social and emotional costs for development. Construction workers in many cases are also paying a high price for their economic benefits. Some of the wives watch television much of the day, during which time they tend to consume many snacks;/71 similarly, many husbands drink and fight. Family relationships often leave a great deal to be desired. Many newcomers acknowledge that they are not strongly family oriented because they have had to leave their families behind or because frequent moving has precluded extended family relationships. There is much frustration, boredom, desertion, depression, and divorce reported. Trailers in some cases are overcrowded or unsanitary. Many newcomers said they were "hanging on" because they wanted to avoid returning to marginal employment situations.

Other strains were noted. One newcomer felt that he and others like him were just as much victims of the situation created by development as local landowners but in different ways, such as being residentially and recreationally deprived. As one person observed, "The park here has no swings or trees—some park!" The bright, blinking lights on the new stack are very annoying to some individuals, and the lack of a shopping center and other facilities at Colstrip is bothersome to the many newcomers who are accustomed to the amenities offered by city life. Many lamented the lack of a choice of anything.

It was reported that a sizeable proportion of workers were saving money "to get out of here" and that it was difficult to develop a sense of feeling at home because:

> . . . the company makes it very hard for us to do so in the temporary trailer area. They seem to think we are nothing; we just need a pile of rocks to be happy, they feel.
>
> (You) try to get by and forget about it. If (you) think a lot about the living situation it just eats at you.

Further, cultivating friends to visit or shop with is difficult when any friends made must soon move away. Thus, it is generally agreed that contacts among newcomers are for the most part superficial and seldom develop into primary, intimate relationships.

Construction workers must accommodate the dictates of a one-company town and reportedly do not like to be told what and what not to do. Some rules are met with defiance. For example, when workers were told that the limited water supply could not support the gardens they wanted (a prohibition which has evidently been moderated with increased water availability), many started hauling both dirt and water that night. Several interviewees suggested that it would be advisable to give Colstrip residents more say about their living and working conditions and a voice in town affairs and planning to ward off the discontent which was already being felt in several ways and causing workers to leave./72 At present, however, workers have little choice but to submit to company rules (which many view as arbitrary, unnecessary, short-sighted or foolish, if not infringing on personal rights) or leave.

Company officials are aware that some of the construction workers have been dissatisfied with life at Colstrip and expect a certain amount of turnover. One stated:

> Many construction workers do not wish to live in Colstrip or anywhere else the remainder of their lifetimes. We have workers making good money, working every day, leaving every day to work on high-paying jobs in Alaska or elsewhere. Many construction workers who wish to stay will have an opportunity to work in the mines as the labor force there increases.

Miners in the area generally subscribe to the same values as those opposing large-scale (i.e., more than "strip and ship") development. They do not want a lot of people coming in. Even though they acknowledge that their jobs would probably be more secure and their pay higher with such increased industrial activity,/73 they prefer the way of life they had before present construction began. Wives mention (and their husbands agree) that they used to look forward to three-day weekends due to shift changes; now, however, their husbands work six days a week. Miners are thus earning more money because of development, but because there is nothing to spend it on they would rather have the free time they had before.

A few newcomers were very enthusiastic about Colstrip, declaring it to have good weather, an interesting mix of people, and good services (church, school, and medical services--the closest of the latter being available at Forsyth, except for Colstrip's first-aid station which registered nurses have been operating for the past several months), whereas comparable construction sites had so much less. Some ranked it low for services offered compared to taxes but did not consider the discrepancy outrageous.

c. Discussion

Over the years ranchers have come to perceive their ties in an unrealistic, romanticized manner, as if their realtionships to neighbors were those of brothers. Coal development has brought out the less pleasant realization that ties between neighbors are, at bottom, more symbiotic than social. This realization calls to their attention another facet of their vulnerability to developmental interventions. Given the weakening of neighborly ties and rural community social structure, it is evident that the traditional "gemeinschaft" type of rural society is being superseded by a much looser form of social organization.

Noteworthy in the many indications of tolerance limits reported concerning industrial activity is the complete agreement among landowners that "people pollution" is the most destructive force that can be directed against their rural way of life. The rancher feels very threatened because a large influx of people will destroy his and his immediate family's ability to continue being physically isolated and socially distant from others and to remain unchallenged in his attachment to his land. Through this attachment, the rancher maintains a feeling of social solidarity with his forebears. Through improving the land, he encourages his offspring to pick up where he leaves off. In this way, the rancher reaffirms his belief that he is fulfilling his responsibility to both the land and its caretakers. The cattle he raises and sells provide him with income needed to maintain this family-centered, man-land relationship. In southeastern Montana, certainly, that is the meaning of ranching.

All ranchers perform a great many functions and play numerous pertinent roles, including the role of businessman. "Business oriented ranchers" are those pro-development individuals who are evidently willing to risk becoming morally detached from the natural community of which they have been a member. The willingness to pay social costs to obtain money is common to these ranchers and the many business oriented oil and construction workers in the study area./74 These workers and ranchers tend to be loyal primarily to themselves, acting to a great extent like "boomers" who justify their way of life by belittling those whose views and traditions are other than their own.

There are also many workers who do not share this attitude. A sizeable proportion of the mine workers at Colstrip who have been on the job for a year and a half or two have begun to noticeably identify and associate much more with the locals than with the new construction people, whose position is much less permanent. Those who are in this cultural convert group anticipate long-term work opportunities and are taking them and related opportunities to become bona fide members of the local community. They are seeking to establish themselves as locals and are absorbing the local values.

Many workers are primarily interested in getting higher wages in order to acquire material possessions. Most of these are not interested in long-range investments or savings. Some work in order to be able to take time off to hunt. In short, work is a means to various ends for most new employees in the study area, who appear to be largely detached from their jobs and willing to stay on only so long as the money is more attractive than that offered by another project. Such an attitude is totally foreign to most ranchers, especially those whose dedication and commitment to their work virtually absorbs their lives.

Changes taking place in the life-styles of people in the study area have been described through showing how they are perceiving and finding meaning in what is or seems to be happening as a result of coal-related development. For example, several months ago Forsyth businessmen were certain that they were entering a long period of substantial economic benefit which they predicted they could achieve at minimal social cost. Now they are beginning to feel the social costs and are less certain that unbridled economic growth is all that it was expected to be. They are beginning to seek ways to have more say in coal developments, realizing increasingly that they have had very little influence in developmental decision-making processes which significantly affect the character, scope, and security of their businesses.

Ranchers in the area who are successful and find it difficult to imagine doing any other work (which applies to most ranchers in the area) are becoming more politically aware in an effort to have more say in shaping events which affect their ability to function as they feel they must. While becoming more politically astute, they are collectivizing their efforts in the traditional "strength through unity" approach to survival. There are definite tendencies to become militant, or at least well organized, as a direct response to the apparently unrelenting interventions of coal industrialists. Such actions have been slow to develop, since ranchers have always preferred to "go it alone" in dealing with their problems. However, they are realizing that their coal-realted problems are collective, not merely individual, and that they need each other's help in interpreting and doing something about these problems, which are evidently too big and dynamic for them to handle individually, even if they had the time, energy, and money to tackle the problems alone.

It cannot be emphasized too strongly that the great majority of ranchers in the study area simply do not believe that there are no good alternatives to industrializing Western coal resources in order to meet national energy needs and cater to national energy desires. Nor can it be stressed too much that these ranchers are terribly frightened of possible and apparently increasingly likely pernicious effects of this industrialization on the physical, biological, and social aspects of their way of life. They are organizing to take political action to safeguard what they consider to be an invaluable personal and national resource: the very productive, but very fragile, grazing land which overlays the vast coal deposits. The ranchers feel that they are in grave danger of being overrun by people who are merely using the present national energy shortage to (in one rancher's words):

> . . . rip up our land in order to rip off the country's coal. There is no good excuse for that kind of destruction and larceny--yes, larceny because they are about to steal the country blind while making everybody think they are some kind of heroes. And while they foolishly use up this nonrenewable resource for manufacturing electricity and such, they will destroy the productivity of our land for God knows how many decades. The damn fools who think that coal will be a tax bonanza to the county or the state had better ask where the tax money is going to come from after this land is made worthless.

Many other ranchers in the study area would agree that the use of Western coal to meet short-run energy requirements is highly questionable, so much so that they are organizing themselves to try to make their concerns and conclusions known to the bureaucrats and politicians who will make land use decisions which will importantly and indeed fatefully affect ranchers (and all other residents of the Northern Great Plains region of the nation).

B. Long-Range Social Impacts

The following scenarios represent three sets of predictions of future social impact in the Colstrip area. The scenarios make no assumptions about such important and relevant matters as federal coal leasing policies which will grow out of the strip mining bill now being designed by Congress; what kind, degree, and rate of coal-related development there will be in and around the Northern Cheyenne Reservation and the Decker-Birney-Ashland area; or what development there may be at Colstrip beyond Units 3 and 4. Water issues are barely alluded to here. The recent spate of letters to the editors of the Billings and Forsyth newspapers written by old and new Colstrip residents to complain about being treated unfairly and/or undemocratically by the company town's management has not even been alluded to in the scenarios.

1. Scenario I

This scenario is based on the assumption that nothing new will be developed in the vicinity of Colstrip. The two existing strip mines will continue their present modes of operation, and the two power plant units now under construction will operate as planned.

During the next ten years in terms of the four principal social categories (social organization, social process, social relationships and life styles), here is what to expect:

1) Temporary newcomers (principally construction workers at Colstrip) will be much in evidence after Unit 1 is completed, probably in late summer or early autumn, 1975. They will almost be completely gone a year later when Unit 2 goes on line.

Their disappearance from the vicinity of Colstrip will produce a number of consequences. Stores in the area will have perceptibly fewer customers, and the housing pressure at Forsyth will ease off noticeably. There will be a sharp decline in the number of mobile homes at Forsyth and a complete disappearance of the "temporary trailer park" at Colstrip. School enrollment will drop dramatically at Colstrip to about its 1972-73 level, and a similar, but less drastic drop will occur at Forsyth, where school enrollment increases have been decidedly smaller. In both cases the departure of construction workers will move the general demand for these services back to where it was early in the construction of Unit 1 (i.e., to the 1972-73 level).

The pressure on landowners between Colstrip and Forsyth to subdivide or otherwise make residential land available to newcomers will grow to the point where a small amount of such land will be sold to them while rumors of industrial expansion in the Colstrip area are still believable. After the rural landowners generally are convinced that nothing beyond Units 1 and 2 will be constructed at or near Colstrip, they will return to their present position of refusing to consider using agricultural land for nonagricultural purposes. The few exceptions that may occur would be for the purpose of making residential land available to some of the miners and other newcomers who appear to be well on the way to achieving the status of long-term residents, but who don't care to live at Colstrip or simply prefer the relative spaciousness and solitude of a rural residence.

2) The miners, employees of MPC, businessmen and others who move into Colstrip and the vicinity with intentions of remaining indefinitely will be the newcomers who will tend to become increasingly like long-time residents who have deep cultural roots in the area. These newcomers gradually will be drawn into established local social circles, and after the last construction workers leave will find it easier to avoid being identified locally with these workers and their strange and disruptive ways. A few years after Unit 2 goes on line, the only locally perceived newcomers will be those who move into the area to replace or join people in coal-related work. These newcomers will be given every opportunity to achieve the status of locals.

Little urbanization will occur during this ten-year period. The culture of new people will be subordinated to the local rural culture, symbolized by the tendency of new members of the local town and rural communities to adopt local styles of dress as well as social behavior in general.

The political scene will be affected minimally by the economic changes here assumed. Long established residents will remain in control of key political positions, although some newly established locals naturally will begin to occupy some such positions as time goes by.

Forsyth will remain the only incorporated town in Rosebud County, since it will be financially advantageous for the others to retain their present financial relationship to the county government. Colstrip gradually will move toward being owned by residents as well as by Western Energy Company, and some form of democratic government may evolve, but the town will contine to be controlled essentially by the company. As the newer locals acquire residential property in and around Colstrip (particularly in Forsyth in the latter case), they will further establish themselves as members of the local society.

3) Established locals in Forsyth will find that their community will continue to be the shopping and business center of the area. Colstrip will offer some "convenience" goods and services, but nothing which will be highly competitive with what Forsyth will offer. Since no businessman in Forsyth will have expanded his firm so much that he is harmed by failure of the Colstrip area to be industrialized more heavily, most Forsyth businessmen will continue to enjoy a level of prosperity beyond the Colstrip construction period, that is substantially above that of the pre-construction years. Bars will do much less business than during the construction period, but with the return of established long-time residents to the bars they avoided during the construction time, bar owners, too, will find themselves doing much better than they did in the pre-construction era. In general, business activity in Forsyth will settle down to a satisfactory level and employment opportunities for local residents will remain good, even after severe labor shortages become a thing of the past.

Late in the 1970's people in Forsyth again will have the pre-construction feeling that they know everybody they see. The return to a rural atmosphere will bring with it the resumption of the practice of leaving houses and cars unlocked, the ability to find a place to park downtown, and the expectation that service at the bank and the stores will be as prompt and as satisfying as it used to be. In short, social costs will decrease much more sharply than will economic benefits after the construction workers are gone. With this realization, most Forsyth residents will be content with the limited degree of industrialization that has taken place. This will be true especially of older persons and others on low, fixed (or slowly rising) incomes, whose taxes seemed destined to rise to the point of making it very difficult or impossible to continue residing in their homes.

The costs of law enforcement and other services directly attributable to the large and rapid influx of construction workers will become much more manageable as the construction period passes. Experiences gained during this period will carry over enough to have a beneficial effect on governmental and nongovernmental service agencies during the post-construction era.

Modernization of water and sewer systems at Forsyth, begun during 1975, will be completed soon afterward and enjoyed by all concerned. The costs of these improvements will be quite manageable owing to the generally greater prosperity of the community. Again, only the elderly and those on a fixed low income will experience such costs as a significant problem.

City planning and county wide planning efforts will not make much headway. Most local residents in and out of the county seat will be relieved when the impacts accompanying coal industrialization ease off and a new state of social adjustment, reflective of the status quo ante, takes hold. Thus, for example, enthusiasm for improving recreational facilities in Forsyth and Colstrip will wane, and people will continue to be left largely to their own devices to deal with problems of boredom, loneliness, and the like.

4) Rural persons will welcome the reduction of threat to their way of life which rapid, large-scale industrialization of coal resources had posed. They will continue to observe the course of actual and attempted industrial development with great care, paying special attention to what happens to the air, water, flora, and fauna as well as to the more direct impacts of development on their way of life. Such landowners' organizations as the Rosebud Protective Association will remain vigilant to protect the members' interests and to insure that the coal and energy companies comply with laws safeguarding the environment. The great problems of the recent past will virtually vanish. Feelings of uncertainty and uncontrollability of life will give way to a partial restoration of traditional rural ways. In short, a working accommodation between the landowners and representatives of industry will be achieved (live and let live), and the ranchers will feel able to invest in ways which they feel will improve substantially the relationships between their families and their land.

During the following twenty years the patterns noted above will continue without significant change. There may be pollution problems which are annoying or even disastrous, but the level of coal development assumed here probably will not produce pollution problems which cannot or will not be effectively resolved.

2. Scenario II

The assumption here is that Units 3 and 4 will not be built at or near Colstrip, but that there will be a substantial increase in the strip mining and exporting of coal from the area.

Even if the work force in the present and future mines in the area increases to twice its present size, the depictions presented in Scenario I will apply almost without change to Scenario II. Problems in coping with newcomers might be expected if the mining activities are in effect doubled while Units 1 and 2 are still under construction. However, it is here assumed that the mining will be expanded slowly before the end of 1976 and more rapidly during the next few years, thus giving long-time local residents an opportunity to cope with the power plants and their personnel without at the same time having to deal with large numbers of other newcomers.

Housing pressure will remain high for a longer period of time in Scenario II than in Scenario I. Many of the new miners will want to live in such towns as Forsyth, Lame Deer, Ashland, or Hardin. Others will renew pressure on landowners in the area to sell parcels of land for residential purposes. Land use planning in the area will be a larger problem of longer duration than in the case of Scenario I.

Businessmen will consider an increase in mining a fairly positive feature since economic activity will be greater than in Scenario I. This will not be without disadvantages, however, since more competition will be attracted to the area in a few types of businesses. Because the additional miners and their families will be dispersed over a large area, Forsyth will experience only a bit more economic growth than in Scenario I, sharing it with the communities just mentioned. Even so, Forsyth merchants will generally feel that this level of economic growth is very close to optimal.

Ranchers will become more concerned about the effects of extensive strip mining and therefore will want to have an increasingly significant voice in decisions concerning where and how much mining will be done. In this way they will hope they can safeguard precious land and water and more closely monitor the progress being made in reclamation. "People pollution" problems will be the subject of discussion among some landowners, but the additional miners generally will be dispersed widely enough and locally socialized well enough for their increased presence to be tolerable except to the few who see only potential trouble wherever the local population is increased.

The schools and other service organizations will be able to manage successfully what will be about a 1973-74 level of service demand. This demand will build up to that level fairly slowly after dropping off sharply at the end of the construction period for Units 1 and 2. The construction personnel associated with the increase in mining will not be present in sufficient numbers at any one time to become the kind of social problem they have been during the past several months.

3. Scenario III

The assumption here is that Units 3 and 4 will be built as planned and that there will be an increase in strip mining to supply these plants as well as some additional out-of-state customers. In short, there will be a continuation of large numbers of construction workers at Colstrip for another three to five years, some additional construction workers during part of this period (and after it) to get more mines into operation, and about as many additional miners as in the case of Scenario II.

Some significant problems which will occur in the area are summarized as follows:

1) Approval of construction of Units 3 and 4 will have an immediate and far reaching social impact on the area. To the ranchers, approval of Units 3 and 4 will symbolize state sanction of the beginning of the end of life as they have known it and wish it to continue. Few ranchers in the area imagine that they can adjust to several more years of life as it has been in the recent past and present. To them Units 3 and 4 would mean that present conditions will only be exacerbated beyond their ability to survive and find

life worthwhile. Some attempt will probably be made by citizens' and environmental groups to have the approval of Units 3 and 4 rescinded. Few ranchers will attempt to wait and see what happens and it is anticipated that many will seek to cut their losses and move as far out of the coal area as they can get.

2) More business competition will be attracted to Forsyth. Many local merchants will strongly resist and resent the appearance of chain store competition.

3) Housing and related pressures for growth will become so great that the city of Forsyth will seek to expand, perhaps even to the other side of the river. Planning problems will be enormous and increasingly difficult to avoid. The city government will face great and continuing financial, leadership, and organizational crises which may lead to adoption of a city manager system and aggressive searches for outside professional and financial assistance.

4) The county too reluctantly will seek to develop its land use planning organization and regulation activities, assisted and supported by landowners who had previously resisted such development.

5) There will be continued growth of such present social problems as those of construction workers' wives in Colstrip and the elderly in Forsyth. Local residents of all description will be joined by some newcomers in trying to attack such problems, but they will experience little success. Needed expertise, social reorganization, and money will not be available and therefore will add to the general feeling that these and other social problems are terrible prices to pay for whatever economic gains the people in the area may enjoy. Some landowners and many retired persons will suffer such economic hardship that they too will become defined in the area as significant, and especially pitiable, social problems.

6) Some landowners, joined by sympathetic townspeople (and perhaps by some nearby reservation Indians), will seek through political, and legal action to stop or greatly slow down construction of Units 3 and 4 and associated mines. In these efforts, political and other forms of human conflict can be expected.

7) The area will, after several years, become observably less agricultural and more industrial. In this regard, it will begin to resemble Campbell County, Wyoming.

8) As Units 3 and 4 become operational, landowners will grow increasingly apprehensive about the effects of stack emissions on the surrounding environment. Court action will be necessary to settle claims of law violations.

9) Townspeople will join landowners in

feeling that the area is no longer theirs. They will begin to feel overwhelmed in the manner now being experienced by locals in Rock Springs, Wyoming.

10) The new industrialists will begin to more openly assume positions of formal and informal leadership in the early part of the 1980's.

11) The model for life-style actually will become more industrial and less agricultural in the 1980's.

C. Colstrip Regional Public Opinion

This section is intended to provide a broad range of information about the attitudes, opinions, and feelings of the people living in parts of Rosebud County that are significantly affected by actual and proposed energy development activities, and should be considered an addition to the preceding ethnographic report of the social impact of coal development in Rosebud County. The area studied includes that portion of the county lying south of the Yellowstone River and north of the Northern Cheyenne Rservation, and the portion of the county south of the reservation. Major population centers are Forsyth in the north and Colstrip in the approximate center of the study area. Secondary concentrations in the southern portion are Ashland, on the eastern border of the reservation, and Birney and Decker, south of the reservation. An estimated 6,000 persons live in the study area.

The study was designed as a survey, utilizing a lengthy questionnaire administered through personal interviews to a sample of people drawn from the study area. The questionnaire was designed to elicit responses to questions from a variety of topics related to energy development, and more specifically to the perceived impact of the construction of Units 3 and 4. Major topics with which the survey was concerned include the following:

1) How people feel about the area in which they live and work.

2) Opinions on a number of issues relating to energy development, such as the effects of industrialization, potential environmental impact, social and economic planning, etc.

3) The impact of development in and around Rosebud County.

4) Recreational activities of people in the area.

5) Factors affecting people's decisions to live in the area and to continue residing there.

6) Sources and adequacy of various social and economic services.

7) Demographic and personal data about respondents, including such items as age, marital and family status, income, education, length of time in the area, etc.

The survey methodology is included in Appendix H2.

1. Presentation of Results

The data from the survey were tabulated by grouping respondents who chose the same option to two items. Essentially the responses to two items are compared. Tables for those items believed to be particularly relevant are presented in the following section. Comments summarizing significant results from these groups of tables are included with the tables.

Generally each item is reported by occupational categories of respondents. Additionally some items are categorized into areas of the county or respondents' length of residence in the study area. Occupations are divided into categories to reflect main groups of common interest existing in the study area. The mining category includes all respondents working in strip mining activities. The permanent Colstrip category includes MPC, Western Energy, and other permanent and nonconstruction employees in Colstrip. The manual construction category includes all nonwhite-collar, nonengineering construction workers, generally those working on Units 1 and 2 or on the pipeline. The nonmanual construction category includes engineers and white-collar construction personnel. Manual and nonmanual are the terms commonly used in Colstrip for such distinctions. The rancher-ranch category includes all ranchers, ranch hands, and farmers sampled. The railroad employee category includes those respondents employed by Burlington Northern. The government employee category includes local, state, and federal employees. The retired category includes all retired respondents. The business category includes those businessmen and professionals in Forsyth. The area-of-county categories are self-explanatory with the exception of two categories: rural, east section, and rural, west section refer to those respondents living outside of Forsyth and Colstrip and east or west of Colstrip.

2. Summary of Results

a. Opinions Concerning Units 3 and 4.

Attitudes toward the approval or disapproval of Units 3 and 4 were examined from several perspectives. One item directly asked what decision should be made about Units 3 and 4.

Only 8.9% felt that Units 3 and 4 should be built unconditionally. A majority, 51.9%, felt that Units 3 and 4 should not be built or should not be built until the effects of Units 1 and 2 are known. When the respondents are divided into occupational categories, three groupings show important results. A large proportion, 83.4%, of the ranchers and ranch hands felt that Units 3 and 4 should not be built or should not be built until the effects of Units 1 and 2 are known. The largest block of manual construction workers, 45.6 %, felt that Units 3 and 4 should be built if the state can enforce strong controls. The largest group of the business category, 46.3% felt that Units 3 and 4 should not be built until the effects of Units 1 and 2 are known. A more complete presentation of the results is available in Table 11-30.

When responses to this item are grouped by length of residence in the study area, two groupings appear important. Of the respondents who had lived in the study area more than eight years, 68.3% felt that Units 3 and 4 should not be built at all or should not be built until the effects of Units 1 and 2 are known. Of those respondents who had lived in the study area three years or less, 65.5 % felt that Units 3 and 4 should be built unconditionally or be built if the state can enforce strong controls. See Table 11-31 for a complete presentation.

Grouping the responses by such characteristics of the respondents as age, sex, education, income, or place of residence in the county does not show important correlations.

The reasons respondents expressed for delaying Units 3 and 4 are presented in Table 11-32. The most frequently selected option is that Units 3 and 4 should be delayed until more is known about the effects of Units 1 and 2 on air and water. This question presents an indication of the relative importance of the various options.

Another key item relates to the respondents' attitudes toward further coal development. Their responses are summarized in Tables 11-33, 11-34 and 11-35. A large group of respondents, 45.8%, feel that further coal development should not include more power generating units. Additional mine-mouth generating sites would be acceptable to 39.6% of the respondents. Only 24% approved of industrial development in addition to power generation. The breakdown into occupational categories showed that 80% of ranchers and ranch hands opposed development beyond mining and exporting coal. The other occupational categories have a wide spread of responses. When the responses to this item are grouped by length of residence, it is evident that a majority, 51.8%, of those who have been in the area for more than four years desire either no further development or limiting development to mining and shipping coal. When the responses are grouped by the area of the county in which the respondent lives (Table 11-35), it is evident that 66.1% of the Colstrip residents, who are predominantly associated with Western Energy operations or power plant construction, favor mine-mouth power plants or unrestricted coal development. A majority, 52.8%, of Forsyth, Rosebud, and Hathaway respondents want coal development restricted to mining and shipping coal.

Age, education, or income of the respondents were not significant factors influencing the responses to this item. However, there is a very high correlation between the attitudes toward construction of Units 3 and 4 and the attitudes toward further development in Montana. A comparison of these two items (Table 11-36) shows that 77.9% who selected options 1 and 2 of question 106 indicating further development should be limited to mining also selected options 3 and 4 of question 158 indicated that Units 3 and 4 should not be built or should not be built until the effects of Units 1 and 2 are known. There is

TABLE 11-30

Attitudes of Rosebud Study Area Residents Toward Construction of Units 3 and 4, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 158. I believe that Units 3 and 4 should:											
(1) Be built unconditionally	1.1	0.6	4.5	0.6	----	----	----	----	2.2	8.9	16
(2) Be built if the state can enforce strong controls	3.4	1.7	10.6	2.8	1.1	0.6	3.9	2.8	5.6	32.4	58
(3) Not be built until the effects of Units 1 and 2 are known	3.9	1.1	5.6	0.6	7.8	1.7	5.0	2.8	10.6	39.1	70
(4) Not be built at all	----	----	0.6	----	7.8	----	0.6	1.7	2.2	12.8	23
(9) Don't know	0.6	----	2.2	----	----	0.6	----	1.2	2.2	6.7	12
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 88.2541; df = 36; p < .001

TABLE 11-31

Attitudes of Rosebud Study Area Residents Toward Construction of Units 3 and 4, by Length of Residence in Study Area

	Length of Residence in Study Area							
	6 months or less	more than 6 months but less than 1 year	1-3 years	4-7 years	8-15 years	16 years or longer	% of Total	N
Question 158. I believe that Units 3 and 4 should:								
(1) Be built unconditionally	1.7	1.1	2.8	0.6	0.6	1.1	8.0	14
(2) Be built if the state can enforce strong controls	4.5	2.8	9.1	5.1	4.5	6.8	33.0	58
(3) Not be built until the effects of Units 1 and 2 are known	2.3	1.1	4.0	5.1	6.8	19.9	39.2	69
(4) Not be built at all	0.6	----	1.7	0.6	3.4	6.8	13.1	23
(9) Don't know	1.1	----	0.6	1.1	0.6	3.4	6.8	12
Total	10.2	5.1	18.2	12.5	15.9	38.1	100.0	
N	18	9	32	22	28	67		176

Chi Square = 36.0411; df = 20; $p < .05$

TABLE 11-32

Attitudes of Rosebud Study Area Residents Toward Delaying Approval of Units 3 and 4

	Number of Responses	% of Total
Question 163. Units 3 and 4 should be delayed until:		
(1) A way is found to involve people who will be affected in decision-making processes	22	8.3
(2) More is known about the effects of Units 1 and 2 on air and water	68	25.6
(3) More is known about water use needs from Yellowstone River	38	14.3
(4) School facilities catch up	21	7.9
(5) More is known about the impact on Indian reservations	3	1.1
(6) More is known about social costs of Units 1 and 2	14	5.2
(7) Better living conditions are provided for construction workers	16	6.0
(8) Land reclamation is assured	31	11.6
(9) Should not be delayed	28	10.5
(10) Should not be granted	17	6.4
(11) Other response	7	2.6
Total	265*	100.0

---

*Total responses exceed 179 because some respondents selected more than one answer.

TABLE 11-33

Attitudes of Rosebud Study Area Residents Toward Further Coal Development, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 106. Assuming that Montana is obliged to help the rest of the nation to meet growing energy needs, there remains the question of the reasonable limits of Montana's obligation. That is, how much coal development in Montana is enough, how much is too much?											
(1) There should be no further development: what we have under way is enough.	1.7	----	2.2	----	4.5	----	2.2	0.6	2.8	14.0	25
(2) Further development should be confined to mining and exporting coal.	2.2	0.6	6.1	----	8.9	1.1	3.9	2.2	6.7	31.8	57
(3) Further development should be confined to mining and mine-mouth power generation.	2.8	0.6	3.9	1.7	0.6	----	1.7	0.6	3.9	15.6	28
(4) Further development should not be restricted, but should be a direct response to what the rest of the nation says it wants.	1.1	1.7	9.5	2.2	0.6	1.1	0.6	2.2	5.0	24.0	43
(5) Don't know	1.1	0.6	----	----	----	----	1.2	2.8	3.5	10.1	18
(6) Other response	----	----	1.7	----	2.2	0.6	----	----	----	4.5	8
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 98.2851; df = 54; p < .001

TABLE 11-34

Attitudes of Rosebud Study Area Residents Toward Further Coal Development, by Length of Residence in Study Area

	Length of Residence in Study Area							
	6 mos. or less	more than 6 mos. but less than 1 yr.	1-3 yrs.	4-7 yrs.	8-15 yrs.	16 yrs. or longer	% of Total	N
Question 106. Assuming that Montana is obliged to help the rest of the nation to meet growing energy needs, there remains the question of the reasonable limits of Montana's obligation. That is, how much coal development in Montana is enough, how much is too much?								
(1) There should be no further development: what we have under way is enough.	1.7	0.6	1.7	2.3	3.4	4.5	14.2	25
(2) Further development should be confined to mining and exporting coal.	0.6	1.1	5.7	2.8	5.1	16.5	31.8	56
(3) Further development should be confined to mining and mine-mouth power generation.	1.1	1.7	4.5	1.7	0.6	6.3	15.9	28
(4) Further development should not be restricted, but should be a direct response to what the rest of the nation says it wants.	4.5	1.7	5.1	2.8	4.5	4.5	23.3	41
(5) Don't know	0.6	----	0.6	2.3	2.2	4.6	10.2	18
(6) Other response	1.7	----	0.6	0.6	----	1.7	4.5	8
Total	10.2	5.1	18.2	12.5	15.9	38.1	100.0	
N	18	9	32	22	28	67		176

Chi Square = 38.9198; df = 30

TABLE 11-35

Attitudes of Rosebud Study Area Residents Toward Further Coal Development, by Area of County

	Area of County								
	Forsyth, Rosebud	Rural, East Section	Rural, West Section	Colstrip, Power Plant Side	Colstrip, Permanent Side	Ashland Area	Birney Area	% of Total	N
Question 106. Assuming that Montana is obliged to help the rest of the nation to meet growing energy needs, there remains the question of the reasonable limits of Montana's obligation. That is, how much coal development in Montana is enough, how much is too much?									
(1) There should be no further development: what we have under way is enough.	7.8	----	2.2	1.1	1.7	0.6	0.6	14.0	25
(2) Further development should be confined to mining and exporting coal.	17.9	1.7	3.9	3.4	2.2	1.1	1.7	31.8	57
(3) Further development should be confined to mining and mine-mouth power generation.	6.0	----	----	2.8	3.9	1.7	0.6	15.6	28
(4) Further development should not be restricted, but should be a direct response to what the rest of the nation says it wants.	6.7	0.6	0.6	8.4	5.6	1.1	1.1	24.0	43
(5) Don't know	7.3	----	----	0.6	0.6	0.6	1.2	9.1	18
(6) Other response	2.3	----	0.6	0.6	0.6	0.6	----	4.5	8
Total	48.0	2.2	7.3	16.8	14.5	5.6	5.0	100.0	
N	86	4	13	30	26	10	9		179

Chi Square = 73.9923; df = 48; p < .01

TABLE 11-36

Attitudes of Rosebud Study Area Residents Toward Further Development, by Attitude Toward Units 3 and 4

	Question 158: I believe that Units 3 and 4 should:						
	Be built unconditionally	Be built if the state can enforce strong controls	Not be built until the effects of Units 1 & 2 are known	Not be built at all	Don't know	% of Total	N
Question 106. Assuming that Montana is obliged to help the rest of the nation to meet growing energy needs, there remains the question of the reasonable limits of Montana's obligation. That is, how much coal development in Montana is enough, how much is too much?							
(1) There should be no further development: what we have under way is enough.	----	2.2	7.3	3.9	0.6	14.0	25
(2) Further development should be confined to mining and exporting coal.	0.6	6.1	18.4	6.1	0.6	31.8	57
(3) Further development should be confined to mining and mine-mouth power generation.	2.2	10.1	2.8	----	0.6	15.6	28
(4) Further development should not be restricted, but should be a direct response to what the rest of the nation says it wants.	5.0	10.6	5.6	0.6	2.2	24.0	43
(5) Don't know	----	2.8	3.4	1.7	2.2	9.1	18
(6) Other response	1.1	0.6	1.7	0.6	0.6	4.5	8
Total	8.9	32.4	39.1	12.8	6.7	100.0	
N	16	58	70	23	12		179

Chi Square = 74.0878; df = 24; p < .001

a similar grouping of those who favor more development and those who support the construction of Units 3 and 4. These results tend to indicate that the respondents' attitudes toward Units 3 and 4 are part of their attitudes toward development in general.

A large group of respondents, 49.7%, felt that "Units 3 and 4 should be built close to those who will use most of the electricity which these units will generate" (Table 11-37). It was explained that this would mean that Units 3 and 4 would certainly be built outside of the study area and probably outside of the state. Almost a third, 31.3%, disagreed with this item. Of those disagreeing, over half, 55.3%, are employed in construction as manuals or nonmanuals.

b. Additional Tables Relating to Units 3 and 4:

Tables 11-38 through 11-42 present additional items relating to Units 3 and 4. These items deal with the potential effects of Units 3 and 4 on ranch life, municipal water supplies, the younger generation's way of life, the feelings of community, and the aesthetics of the area.

i. Colstrip

Two items relate to attitudes toward Colstrip in General (Tables 11-43 through 11-45). A majority of respondents, 57.5%, feel that Units 3 and 4 should be built in "a company-owned town because it prevents growth of shanty towns and development is more orderly" (Table 11-43). The assumption that company-owned towns prevent the growth of shanty towns and that development in company-owned towns is more orderly was implied by the questionnaire. Interviewers received comments from respondents to the effect that this assumption is an erroneous one. Further research will be needed to determine whether respondents favor the concept of company-owned towns or whether they favor orderly development and the prevention of shanty towns.

A majority of the respondents, 60.3%, feel that MPC is more interested in earning dollars than in providing a good community (Tables 11-44 and 11-45). Of the people living in Colstrip, 55.6% felt this way. Only 15.1% feel that MPC is more interested in "providing a good community than earning dollars." The respondents are fairly evenly split on the question of adequate facilities in the construction trailer courts (Table 11-46). Further research is needed to determine how the respondents, particularly those living in the construction trailer courts, define "adequate facilities". Some respondents said that since they had water, power, and sewer hookups, facilities were adequate. Other respondents strongly complained about the lack of commercial services, playgrounds, a safe walkway for their children, and the school.

When respondents were asked to judge, based on their observations of Colstrip, how sensitive MPC is to the "needs and concerns of people who live close together...," a majority, 53.6%, of Colstrip residents responded that MPC was sensitive (Table 11-47). In contrast, 73.2% of the Forsyth respondents disagreed (Table 11-48). A majority of those living in Colstrip feel that their living conditions "leave a lot to be desired." A large majority, 91.1%, of the Colstrip respondents feel more indoor recreational

TABLE 11-37

Attitudes of Rosebud Study Area Residents Toward Location of Units 3 and 4 Outside of Montana, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 175. Units 3 and 4 should be built close to those who will use most of the electricity which these units will generate:											
(1) Strongly agree	----	----	0.6	----	7.3	----	1.1	----	2.2	11.2	20
(2) Agree	5.6	1.1	5.0	----	7.3	1.1	5.0	4.5	8.9	38.5	69
(3) Neutral	0.6	0.6	3.9	----	1.7	1.1	1.1	1.7	6.1	16.8	30
(4) Disagree	2.8	1.7	12.3	3.9	0.6	----	2.2	1.7	4.5	29.6	53
(5) Strongly disagree	----	----	1.1	----	----	----	----	----	0.6	1.7	3
(6) Don't know	----	----	0.6	----	----	0.6	----	0.6	0.6	2.2	4
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 103.0300; df = 45; p < .001

TABLE 11-38

Rosebud Study Area Residents' Perceptions of the Potential Coexistence of Four Power Generation Units and Ranching Operations, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 129. It is likely that the four power generating units and the related strip mining activities could operate in this area without harmfully affecting existing ranching operations:											
(1) Strongly agree	0.6	0.6	3.4	0.6	----	----	0.6	----	0.6	6.1	11
(2) Agree	5.0	2.2	13.4	3.4	2.2	1.1	3.4	2.8	11.7	45.3	81
(3) Neutral	1.7	0.6	1.1	----	2.2	0.6	3.4	1.7	5.0	16.2	29
(4) Disagree	1.1	----	3.4	----	7.3	1.1	1.1	3.9	3.9	21.8	39
(5) Strongly disagree	----	----	1.7	----	5.0	----	1.1	----	0.6	8.4	15
(6) Don't know	0.6	----	0.6	----	----	----	----	----	1.1	2.2	4
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 82.6093; df = 45; p < .001

TABLE 11-39

Rosebud Study Area Residents' Perceptions of the Possible Effects of Units 3 and 4 on Municipal Water Supplies, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 198. Units 3 and 4 would adversely effect the municipal water supply. (Forsyth and Colstrip)											
(1) Strongly agree	----	----	0.6	----	2.2	----	2.2	----	0.6	5.6	10
(2) Agree	3.4	0.6	2.8	----	10.1	1.1	3.9	3.4	10.1	35.2	63
(3) Neutral	0.6	1.1	5.6	----	1.1	----	1.1	0.6	4.5	14.5	26
(4) Disagree	5.0	1.1	12.8	3.4	0.6	0.6	1.7	2.3	5.6	33.0	59
(5) Strongly disagree	----	0.6	----	----	----	----	----	----	----	0.6	1
(6) Don't know	----	----	1.7	0.6	2.8	1.1	0.6	2.2	2.2	11.2	20
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 110.7010; df = 45; p < .001

TABLE 11-40

Attitudes of Rosebud Study Area Residents Toward the Effect of Units 3 and 4 on the Younger Generation's Way of Life, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 201. The building and operation of Units 3 and 4 would have a good effect on the younger generation's way of life:											
(1) Strongly agree	0.6	0.6	1.7	----	----	----	----	----	----	2.8	5
(2) Agree	2.2	0.6	8.4	2.2	1.1	1.1	2.2	2.3	4.5	24.6	44
(3) Neutral	4.5	1.1	8.9	1.1	1.7	----	3.4	2.2	10.1	33.0	59
(4) Disagree	1.7	1.1	4.5	----	9.5	0.6	3.4	3.4	6.7	30.7	55
(5) Strongly disagree	----	----	----	----	3.4	0.6	0.6	----	0.6	5.0	9
(6) Don't know	----	----	----	0.6	1.1	0.6	----	0.6	1.1	3.9	7
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 76.1873; df = 45; $p < .01$

TABLE 11-41

Rosebud Study Area Residents' Perceptions of the Possible Effects of Units 3 and 4 on Their Feeling of Community, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 202. The building and operation of Units 3 and 4 would decrease your feeling of being part of the community:											
(1) Strongly agree	----	----	----	----	2.2	----	----	----	----	2.2	4
(2) Agree	1.1	----	2.2	0.6	7.3	0.6	2.2	1.7	3.9	19.6	35
(3) Neutral	1.1	1.1	1.7	----	2.8	----	2.2	1.7	3.9	14.5	26
(4) Disagree	6.7	1.7	16.2	3.4	4.5	2.2	4.5	4.5	13.4	57.0	102
(5) Strongly disagree	----	0.6	2.8	----	----	----	----	----	0.6	3.9	7
(6) Don't know	----	----	0.6	----	----	----	0.6	0.6	1.1	2.8	5
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 70.3026; df = 45; $p < .01$

TABLE 11-42

Rosebud Study Area Residents' Perceptions of the Effect Units 3 and 4 Would Have on the Aesthetics of the Area, by Length of Residence in Study Area

	Length of Residence in Study Area							
	6 months or less	more than 6 months but less than 1 year	1-3 years	4-7 years	8-15 years	16 years or longer	% of Total	N
Question 207. Units 3 and 4 would have an adverse effect with aesthetics of the area:								
(1) Strongly agree	1.1	----	0.6	0.6	1.1	3.4	6.8	12
(2) Agree	2.8	1.7	5.7	4.0	6.3	15.3	35.8	63
(3) Neutral	----	1.1	6.8	1.1	0.6	6.8	16.5	29
(4) Disagree	6.3	2.3	4.5	6.8	7.4	9.1	36.4	64
(5) Strongly disagree	----	----	0.6	----	----	----	0.6	1
(6) Don't know	----	----	----	----	0.6	3.4	4.0	7
Total	10.2	5.1	18.2	12.5	15.9	38.1	100.0	
N	18	9	32	22	28	67		176

Chi Square = 40.7152; df = 25; $p < .05$

TABLE 11-43

Attitudes of Rosebud Study Area Residents Toward Construction of Units 3 and 4 in a Company-Owned Town, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 183. It is better for the construction of Units 3 and 4 to be in a company-owned town because it prevents growth of shanty towns and development is more orderly:											
(1) Strongly agree	1.7	0.6	1.7	----	0.6	----	----	----	0.6	5.0	9
(2) Agree	5.6	1.1	12.8	2.8	7.8	1.1	5.6	5.6	10.1	52.5	94
(3) Neutral	----	----	1.1	0.6	1.1	----	2.2	----	6.1	11.2	20
(4) Disagree	1.7	1.7	5.6	0.6	5.6	1.1	1.7	1.1	4.5	23.5	42
(5) Strongly disagree	----	----	1.7	----	----	----	----	0.6	----	2.2	4
(6) Don't know	----	----	0.6	----	1.1	0.6	----	1.1	1.7	5.0	9
(7) Objected to the item	----	----	----	----	0.6	----	----	----	----	0.6	1
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 59.3591; df = 30

TABLE 11-44

Attitudes of Rosebud Study Area Residents Toward Montana Power Company's Administration of Colstrip, by Area of County

	Area of County								
	Forsyth, Rosebud	Rural, East Section	Rural, West Section	Colstrip, Power Plant Side	Colstrip, Permanent Side	Ashland Area	Birney Area	% of Total	N
Question 168. The town of Colstrip is a good example for showing that Montana Power Company is more interested in providing a good community than in earning dollars:									
(1) Strongly agree	0.6	----	----	0.6	----	----	----	1.1	2
(2) Agree	6.7	----	----	1.7	3.9	1.1	0.6	14.0	25
(3) Neutral	11.7	0.6	0.6	4.5	1.7	0.6	1.1	20.7	37
(4) Disagree	21.3	1.1	3.9	8.4	5.0	1.7	1.7	43.0	77
(5) Strongly disagree	5.6	0.6	2.8	1.7	3.3	1.7	1.7	17.3	31
(6) Don't know	2.8	----	----	----	0.6	0.6	----	3.9	7
Total	48.6	2.2	7.3	16.8	14.5	5.6	5.0	100.0	
N	87	4	13	30	26	10	9		179

Chi Square = 31.1119; df = 40

TABLE 11-45

Attitudes of Rosebud Study Area Residents Toward Montana Power Company's Administration of Colstrip, by Occupational Category

	Occupational Category									
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 168. The town of Colstrip is a good example for showing that Montana Power Company is more interested in providing a good community than in earning dollars:											
(1) Strongly agree	0.6	----	----	----	----	----	----	----	0.6	1.1	2
(2) Agree	1.1	1.1	3.9	1.1	----	1.7	0.6	1.7	2.8	14.0	25
(3) Neutral	1.1	----	5.6	1.1	2.2	----	1.7	2.3	6.7	20.7	37
(4) Disagree	6.1	1.7	8.9	0.6	8.9	0.6	5.0	3.4	7.8	43.0	77
(5) Strongly disagree	----	0.6	5.0	0.6	5.0	----	2.2	----	3.9	17.3	31
(6) Don't know	----	----	----	0.6	0.6	0.6	----	1.1	1.1	3.9	7
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 54.9438; df = 45

TABLE 11-46

Attitudes of Rosebud Study Area Residents Toward Living Conditions in Construction Trailer Courts, by Occupational Category

	Occupational Category									
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 188. Living conditions in the construction trailer courts are not good because adequate facilities have not been provided for the workers:											
(1) Strongly agree	----	----	3.4	0.6	1.1	0.6	0.6	----	0.6	6.7	12
(2) Agree	3.9	1.1	6.7	1.1	9.5	0.6	3.4	1.1	7.8	35.2	63
(3) Neutral	1.1	0.6	0.6	----	2.2	----	1.1	1.7	5.6	12.8	23
(4) Disagree	2.8	1.7	12.3	2.2	2.2	1.1	3.9	3.4	4.5	34.1	61
(5) Strongly disagree	1.1	----	----	----	----	----	----	----	0.6	1.7	3
(6) Don't know	----	----	0.6	----	1.7	0.6	0.6	2.2	3.9	9.5	17
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 71.9702; df = 45; p < .01

TABLE 11-47

Rosebud Study Area Residents' Perceptions of Montana Power Company's Sensitivity to the Needs of Colstrip Residents, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 164. Judging from your observations of how Colstrip has developed, how sensitive to the needs and concerns of people who live close together do you think Montana Power is?											
(1) Very sensitive	0.6	1.7	2.8	----	----	0.6	----	0.6	1.7	7.8	14
(2) Sensitive	3.9	----	8.4	1.7	3.4	1.7	2.8	2.2	6.7	30.7	55
(3) Neither sensitive nor unsensitive	3.9	1.7	5.0	----	2.2	----	2.2	1.1	5.6	21.8	39
(4) Unsensitive	0.6	----	2.2	1.7	3.4	0.6	3.9	1.1	3.9	17.3	31
(5) Very unsensitive	----	----	4.5	----	5.0	----	0.6	0.6	3.4	14.0	25
(9) Don't know	----	----	0.6	0.6	2.8	----	----	2.8	1.7	8.4	15
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 116.6250; df = 54; p < .001

TABLE 11-48

Attitudes of Rosebud Study Area Residents Toward Their Living Conditions, by Area of County

	Area of County								
	Forsyth, Rosebud	Rural, East Section	Rural, West Section	Colstrip, Power Plant Side	Colstrip, Permanent Side	Ashland Area	Birney Area	% of Total	N
Question 10. My living conditions here leave a lot to be desired:									
(1) Strongly agree	1.1	----	1.7	3.4	1.1	----	----	7.3	13
(2) Agree	8.4	----	1.1	6.1	5.6	1.7	1.7	24.6	44
(3) Neutral	2.2	----	----	1.7	1.7	----	----	5.6	10
(4) Disagree	34.1	1.7	3.9	5.0	5.1	3.9	2.2	55.9	100
(5) Strongly disagree	1.7	0.6	0.6	0.6	1.1	----	1.1	5.6	10
(6) Don't know	1.1	----	----	----	----	----	----	1.1	2
Total	48.6	2.2	7.3	16.8	14.5	5.6	5.0	100.0	
N	87	4	13	31	26	10	9		179

Chi Square = 53.6664; df = 40

facilities would be desirable. A majority, 74.4%, of the Forsyth respondents agree that more indoor recreational facilities would be desirable (Table 11-49). Similarly, a large majority, 86.2%, of Colstrip respondents feel that more outdoor recreational facilities would be desirable. A majority, 63.4%, in Forsyth agree (Table 11-50. When asked who should provide additional recreational facilities, 37.5% said that MPC and the construction companies should. An additional 39.7% favored some combination of county, MPC and construction companies (Table 11-51).

A third of the respondents, 34.6%, feel that the "local economic costs of industrialization of coal resources..." should be paid by a combination of industry, all levels of governments, and electric power consumers. The second largest group of respondents, 21.8%, feel that industry alone should pay the costs (Table 11-52).

The subject of housing produced strong responses in Colstrip and Forsyth. A large majority of all respondents, 71.5%, indicate that a shortage of public housing is a problem in the area. In Colstrip, 78.6% expressed concern about housing. In Forsyth, 70.9% indicate a similar concern (Table 11-53).

c. Education

The potential effects of Units 3 and 4 on the area's educational system is of serious concern to the respondents. Presently, 45.3% of the respondents agreed, "We have an excellent school system." Only 28.5% disagreed (Table 11-54). However, a strong majority, 82.5%, feel that the construction of Units 3 and 4 will cause serious crowding of schools (Table 11-55), a uniform concern throughout the county. A majority, 60.8%, feel that the building of Units 3 and 4 would increase the amount that they pay to support schools (Table 11-56), again a uniform response throughout the study area. A large group, 46.4%, feel that the development of Units 3 and 4 would not improve the quality of the area's education. The other respondents were divided with 28.5% feeling that this development would improve the area's education and 25.5% undecided or neutral (Table 11-57).

d. Medical and Dental

Medical and dental services were of serious concern to many respondents. Two-thirds, 66.5%, feel that the area has less than excellent health and medical care (Table 11-58). Of those in Colstrip, 80.5% expressed this concern. Of those in Forsyth, 53.1% expressed a similar concern. In the Ashland area, all of the respondents feel this way.

A large majority, 65.4%, feel that the area needs a more fully developed health program (Table 11-59). It was explained to respondents that this meant a county health program. Again this concern was nearly uniform throughout the study area.

When asked whether or not the building of Units 3 and 4 would improve the quality and availability of medical and dental services, the responses were mixed (Tables 11-60 and 11-61). Further research is needed to determine the meaning of these results. The interviewers received many concerned comments in Colstrip about the lack of a doctor in town. Investigation of where respondents go for medical and dental

TABLE 11-49

Attitudes of Rosebud Study Area Residents Toward the Need for More Indoor Recreational Facilities, by Area of County

	Area of County								
	Forsyth, Rosebud	Rural, East Section	Rural, West Section	Colstrip, Power Plant Side	Colstrip, Permanent Side	Ashland Area	Birney Area	% of Total	N
Question 13. More indoor recreational facilities would be desirable:									
(1) Strongly agree	5.6	----	----	7.8	2.2	0.6	----	16.2	29
(2) Agree	30.7	1.1	5.6	7.3	11.1	5.0	3.4	64.2	115
(3) Neutral	3.9	----	1.1	1.7	----	----	0.6	7.3	13
(4) Disagree	6.1	----	0.6	----	1.1	----	0.6	8.4	15
(5) Strongly disagree	1.1	1.1	----	----	----	----	0.6	2.8	5
(6) Don't know	1.1	----	----	----	----	----	----	1.1	2
Total	48.6	2.2	7.3	16.8	14.5	5.6	5.0	100.0	
N	87	4	13	30	26	10	9		179

Chi Square = 85.8982; df = 40; $p < .001$

TABLE 11-50

Attitudes of Rosebud Study Area Residents Toward the Need for More Outdoor Recreational Facilities, by Area of County

	Area of County								
	Forsyth, Rosebud	Rural, East Section	Rural, West Section	Colstrip, Power Plant Side	Colstrip, Permanent Side	Ashland Area	Birney Area	% of Total	N
Question 12. More outdoor recreational facilities would be desirable:									
(1) Strongly agree	2.8	----	----	6.1	2.8	----	----	11.7	21
(2) Agree	28.0	0.6	3.9	8.9	9.5	3.4	2.2	56.4	101
(3) Neutral	6.1	----	1.1	1.7	1.1	----	1.1	11.2	20
(4) Disagree	11.2	0.6	2.2	----	1.2	2.2	1.1	18.4	33
(5) Strongly disagree	0.6	1.1	----	----	----	----	0.6	2.2	4
Total	48.6	2.2	7.3	16.8	14.5	5.6	5.0	100.0	
N	87	4	13	30	26	10	9		179

Chi Square = 89.5602; df = 32; $p < .001$

TABLE 11-51

Attitudes of Rosebud Study Area Residents Toward Financing of Increased Recreational Facilities, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 140. Increased needs for recreation facilities should be provided by:											
(1) Construction companies	----	----	0.6	----	1.7	0.6	0.6	----	1.1	4.5	8
(2) Montana Power Company and Western Energy	3.4	1.1	10.1	1.7	7.3	0.6	1.1	3.4	4.5	33.0	59
(3) County taxes	1.1	----	1.1	----	1.1	0.6	0.6	1.1	2.8	8.4	15
(4) Other (specify)	----	1.1	3.9	1.1	----	0.6	0.6	0.6	2.2	10.1	18
(5) More than one of the above	3.9	1.1	7.3	1.1	6.1	0.6	6.7	1.7	11.2	39.7	71
(9) Don't know	0.6	----	0.6	----	0.6	----	----	1.7	1.1	4.5	8
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 66.7466; df = 45; p < .05

TABLE 11-52

Attitudes of Rosebud Study Area Residents Toward Payment of Local Economic Costs of Industrialization of Coal Resources, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 108. In general, and as a rule, who should pay the local economic costs of industrialization of coal resources (e.g., expansion of law enforcement, public health, and educational services)?											
(1) Industry	1.1	0.6	5.6	----	5.6	1.7	2.2	1.7	3.4	21.8	39
(2) Local government	0.6	----	----	----	----	0.6	----	----	1.7	2.8	5
(3) State government	1.1	0.6	1.7	----	----	0.6	----	----	1.7	5.6	10
(4) Federal government	0.6	----	0.6	----	----	----	----	0.6	1.1	2.8	5
(5) The people who directly benefit from the power produced by the coal development	1.1	0.6	2.2	----	3.4	----	2.8	3.4	3.4	16.8	30
(6) All of the above	3.4	1.7	8.9	2.8	2.2	----	3.9	2.2	9.5	34.6	62
(7) None of the above (indicate who should pay in this case)	0.6	----	2.2	----	----	----	----	----	0.6	3.4	6
(8) Some combination other than all of the above	0.6	----	1.1	1.1	5.6	----	0.6	----	----	8.9	16
(9) Don't know	----	----	1.1	----	----	----	----	0.6	1.7	3.4	6
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 126.7106; df = 72; p < .001

TABLE 11-53

Attitudes of Rosebud Study Area Residents Toward Public Housing, by Area of County

	Area of County								
	Forsyth, Rosebud	Rural, East Section	Rural, West Section	Colstrip, Power Plant Side	Colstrip, Permanent Side	Ashland Area	Birney Area	% of Total	N
Question 23. Public housing is not a problem here:									
(1) Strongly agree	2.2	----	----	----	----	----	0.6	2.8	5
(2) Agree	8.4	1.7	2.2	2.8	1.7	0.6	1.7	19.0	34
(3) Neutral	2.2	----	----	1.7	----	0.6	----	4.5	8
(4) Disagree	24.6	----	3.4	8.9	10.1	4.5	1.7	53.1	95
(5) Strongly disagree	10.1	----	1.7	3.4	2.2	----	1.1	18.4	33
(6) Don't know	1.1	0.6	----	----	0.6	----	----	2.2	4
Total	48.6	2.2	7.3	16.8	14.5	5.6	5.0	100.0	
N	87	4	13	30	26	10	9		179

Chi Square = 45.4907; df = 40

TABLE 11-54

Attitudes of Rosebud Study Area Residents Toward the Quality of the School System, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 5. We have an excellent school system:											
(1) Strongly agree	----	0.6	0.6	----	1.1	----	0.6	----	----	2.8	5
(2) Agree	3.4	----	7.3	0.6	6.1	0.6	6.1	5.0	13.4	42.5	76
(3) Neutral	1.1	1.1	7.3	0.6	1.7	1.1	0.6	1.7	3.4	18.4	33
(4) Disagree	2.2	0.6	3.9	1.7	5.0	----	1.7	1.1	5.6	21.8	39
(5) Strongly disagree	1.1	0.6	2.2	0.6	1.1	----	----	0.6	0.6	6.7	12
(6) Don't know	1.1	0.6	2.2	0.6	1.7	1.1	0.6	----	----	7.8	14
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 57.0835; df = 45

TABLE 11-55

Rosebud Study Area Residents' Perceptions of Potential Crowding of Schools, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 193. The construction of Units 3 and 4 will cause serious crowding of the schools:											
(1) Strongly agree	1.7	0.6	2.8	----	6.1	0.6	2.8	0.6	1.7	16.8	30
(2) Agree	6.7	2.2	12.3	2.8	10.1	1.1	6.1	5.6	16.8	63.7	114
(3) Neutral	----	0.6	3.4	----	0.6	----	0.6	0.6	2.2	7.8	14
(4) Disagree	0.6	----	4.5	1.1	----	----	----	0.6	1.7	8.4	15
(5) Strongly disagree	----	----	----	----	----	----	----	----	0.6	0.6	1
(6) Don't know	----	----	0.6	----	----	1.1	----	1.1	----	2.8	5
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 87.1167; df = 45; p < .001

TABLE 11-56

Rosebud Study Area Residents' Perceptions of the Possible Effects of Units 3 and 4 on School Funding, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 195. The building of Units 3 and 4 will increase the amount that you pay to support the schools:											
(1) Strongly agree	----	----	0.6	----	5.0	0.6	----	----	----	6.1	11
(2) Agree	5.0	1.1	11.2	----	9.5	1.1	6.7	4.5	15.6	54.7	98
(3) Neutral	1.7	1.1	6.1	1.1	1.1	----	1.1	1.1	3.4	16.8	30
(4) Disagree	2.2	1.1	3.9	2.2	0.6	----	1.1	1.7	2.8	15.6	28
(5) Strongly disagree	----	----	0.6	----	----	----	0.6	----	0.6	1.7	3
(6) Don't know	----	----	1.1	0.6	0.6	1.1	----	1.1	0.6	5.0	9
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 87.5030; df = 45; p < .001

TABLE 11-57

Rosebud Study Area Residents' Perceptions of the Potential Effect of Units 3 and 4 on the Quality of Education, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 194. The development of Units 3 and 4 will improve the quality of the area's education:											
(1) Strongly agree	----	----	2.2	----	----	----	----	----	0.6	2.8	5
(2) Agree	3.9	1.1	9.5	2.8	0.6	----	2.8	1.7	3.4	25.7	46
(3) Neutral	1.7	0.6	3.4	0.6	1.1	----	2.2	2.8	7.3	19.6	35
(4) Disagree	3.4	1.1	5.6	0.6	11.7	2.2	3.4	2.2	10.6	40.8	73
(5) Strongly disagree	----	----	1.7	----	2.8	----	0.6	----	0.6	5.6	10
(6) Don't know	----	0.6	1.1	----	0.6	0.6	0.6	1.7	0.6	5.6	10
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 77.7658; df = 45; p < .001

TABLE 11-58

Attitudes of Rosebud Study Area Residents Toward the Area's Medical Care, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 14. This area has excellent health and medical care:											
(1) Strongly agree	----	----	----	----	1.1	----	----	----	0.6	1.7	3
(2) Agree	2.2	0.6	2.2	----	1.7	1.1	1.7	2.2	5.0	16.8	30
(3) Neutral	0.6	----	3.4	----	1.7	----	2.2	----	5.0	12.8	23
(4) Disagree	3.4	2.8	12.3	1.1	10.1	1.1	4.5	5.6	9.5	50.3	90
(5) Strongly disagree	2.2	----	5.6	2.8	1.7	----	1.1	----	2.8	16.2	29
(6) Don't know	0.6	----	----	----	0.6	0.6	----	----	----	1.7	3
(7) Other response	----	----	----	----	----	----	----	0.6	----	0.6	1
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 75.4761; df = 54; $p < .05$

TABLE 11-59

Attitudes of Rosebud Study Area Residents Toward the County Health Program, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 17. This area needs a more fully developed health program:											
(1) Strongly agree	1.7	0.6	6.1	----	0.6	----	1.7	----	1.7	12.3	22
(2) Agree	6.1	2.8	12.3	2.8	7.3	2.2	5.6	3.9	10.1	53.1	95
(3) Neutral	----	----	1.1	1.1	3.4	0.6	1.1	0.6	4.5	12.3	22
(4) Disagree	1.1	----	2.8	----	2.8	----	1.1	4.0	6.1	17.9	32
(5) Strongly disagree	----	----	0.6	----	0.6	----	----	----	----	1.1	2
(6) Don't know	----	----	0.6	----	2.2	----	----	----	0.6	3.4	6
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5.	17	15	41		179

Chi Square = 58.1594; df = 45; $p < .05$

TABLE 11-60

Rosebud Study Area Residents' Perceptions of the Possible Effects of Units 3 and 4 on Medical Services, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 196. The building of Units 3 and 4 would improve the quality and availability of medical services:											
(1) Strongly agree	0.6	----	1.1	0.6	----	----	0.6	----	0.6	3.4	6
(2) Agree	4.5	1.7	14.0	1.7	2.8	----	3.9	1.7	5.6	35.8	64
(3) Neutral	2.2	0.6	4.5	0.6	1.7	----	2.8	1.7	5.6	19.6	35
(4) Disagree	1.7	1.1	3.9	1.1	10.6	1.1	2.2	2.8	6.7	31.3	56
(5) Strongly disagree	----	----	----	----	1.1	----	----	----	0.6	1.7	3
(6) Don't know	----	----	----	----	0.6	1.7	----	2.2	3.9	8.4	15
Total	8.9	3.4	23.9	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 82.8034; df = 45; p < .001

TABLE 11-61

Rosebud Study Area Residents' Perceptions of the Possible Effects of Units 3 and 4 on Dental Services, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 197. The building of Units 3 and 4 would improve the quality and availability of dental services:											
(1) Strongly agree	0.6	----	1.1	0.6	----	----	0.6	----	0.6	3.4	6
(2) Agree	4.5	1.7	12.8	1.7	2.2	----	3.4	1.7	5.0	33.0	59
(3) Neutral	2.2	0.6	3.9	0.6	1.7	----	2.8	1.7	5.6	19.0	34
(4) Disagree	1.7	1.1	5.0	1.1	11.7	1.1	2.8	2.8	7.3	34.6	62
(5) Strongly disagree	----	----	0.6	----	1.1	----	----	----	0.6	2.2	4
(6) Don't know	----	----	----	----	----	1.7	----	2.2	3.9	7.8	14
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 85.6145; df = 45; p < .001

services revealed that for medical services, 40.4% go to Forsyth, 33.1% go to Miles City, and 19.5% go to Billings. For dental services 40.1% go to Miles City and 35.7% go to Forsyth.

e. Highways

The quality of roads in the study area is a serious concern. A large majority, 80.5%, expressed concern about the quality of road construction and maintenance (Table 11-62). About one-third of all respondents, 34.1%, indicated strong feeling on this item. Respondents did not express concern about traffic in the area in general. However, interviewers received many comments about traffic on Highway 315 between Colstrip and Forsyth.

Over two-thirds, 69.3%, of respondents feel that MPC should be required to pay "a significant share of the cost of repairing the road damage its industrial activities have caused" (Table 11-63). This attitude was uniform throughout the occupational categories.

f. Taxation

A majority, 52%, of respondents feel that their taxes would go up either slightly or substantially if Units 3 and 4 are constructed (Table 11-64). Of the other respondents, only 11.7% feel that their taxes would go down and 27.9% thought that their taxes would be unaffected. A large group of the Colstrip residents, 44.6%, feel that their taxes would be unaffected. A majority of Forsyth respondents, 52.3%, feel that their taxes would go up.

The respondents do not appear to understand the manner in which the coal tax revenue is distributed. A majority, 58.1%, had no opinion about the fairness of the way that tax revenue is being distributed. Of those respondents expressing an opinion on this item, 74.6% feel that the tax revenue from the coal is being distributed unfairly. There is no large grouping of responses about the effect of Units 3 and 4 on the distribution of tax revenues to local areas.

As noted in the education section, 60.8% feel that the construction of Units 3 and 4 would increase the amount they pay to support the schools.

g. Size of Population Influx

When respondents were asked to estimate the size of the population influx during the construction phase of Units 3 and 4, the responses are surprisingly uniform over the possible range. Better than one-fourth, 26.8%, say that they have no idea; 17.3% think the influx would be over 4,000 and 12.3% expected under 1,000. The responses were quite evenly distributed by place of residence in the county and by attitudes toward construction of Units 3 and 4. Presently the respondents are quite evenly divided on the question of whether or not population growth presents a problem to the study area (Table 11-65). These data, combined with comments from respondents, indicate that area residents have no consensus of what size population influx to expect. This lack of knowledge has serious implications for the area's ability to plan for development.

TABLE 11-62

Attitudes of Rosebud Study Area Residents Toward the Quality of Road Construction and Maintenance, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 7. The quality of road construction and maintenance is very high in this area:											
(1) Strongly agree	----	----	----	----	1.1	----	----	----	----	1.1	2
(2) Agree	0.6	----	1.7	1.1	2.2	1.1	----	2.8	2.8	12.3	22
(3) Neutral	----	----	0.6	----	0.6	----	1.1	0.6	3.4	6.1	11
(4) Disagree	4.5	1.7	9.5	0.6	8.4	0.6	5.0	3.9	12.3	46.4	83
(5) Strongly disagree	3.9	1.7	11.7	2.2	4.5	1.1	3.4	1.1	4.5	34.1	61
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 51.3344; df = 36; $p < .05$

TABLE 11-63

Attitudes of Rosebud Study Area Residents Toward Montana Power Company's Responsibility for Repairs to Highway 315, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 172. Highway 315 in the vicinity of Colstrip is not more Montana Power Company's responsibility than that of others in the county. Accordingly, Montana Power should not be asked or required to pay a significant share of the cost of repairing the road damage its industrial activities have caused:											
(1) Strongly agree	0.6	----	----	0.6	0.6	----	----	----	1.7	3.4	6
(2) Agree	2.8	1.1	4.5	1.1	----	1.1	1.7	2.2	5.0	19.6	35
(3) Neutral	----	----	1.1	1.1	1.7	0.6	0.6	0.6	1.1	6.7	12
(4) Disagree	5.0	2.2	12.8	1.1	8.9	1.1	3.9	2.2	12.8	50.3	90
(5) Strongly disagree	0.6	----	5.0	----	5.6	----	3.4	2.2	2.2	19.0	34
(6) Don't know	----	----	----	----	----	----	----	1.1	----	1.1	2
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 80.7985; df = 45; p < .001

TABLE 11-64

Rosebud Study Area Residents' Perceptions of the Potential Effect of Units 3 and 4 on Their Taxes, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 166. If Units 3 and 4 are constructed, my taxes probably will:											
(1) Go down substantially	----	----	----	----	----	----	0.6	----	0.6	1.1	2
(2) Go down slightly	0.6	0.6	2.2	----	2.2	----	1.1	1.1	2.8	10.6	19
(3) Be unaffected	2.2	1.7	8.4	2.2	1.7	1.1	3.4	0.6	6.7	27.9	50
(4) Go up slightly	5.0	0.6	8.9	1.7	3.9	1.1	1.7	2.8	7.3	33.0	59
(5) Go up substantially	----	----	2.2	----	7.8	----	2.2	1.7	5.0	19.0	34
(9) Don't know	1.2	0.6	1.7	----	1.1	0.6	0.6	2.2	0.6	8.4	15
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 80.2463; df = 54; p < .01

TABLE 11-65

Attitudes of Rosebud Study Area Residents Toward Population Growth in the Study Area, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 30. Population growth in this area presents no problem:											
(1) Strongly agree	----	----	0.6	----	0.6	----	----	----	0.6	1.7	3
(2) Agree	2.2	1.7	9.5	2.8	6.1	1.1	2.8	6.1	9.5	41.9	75
(3) Neutral	0.6	----	2.8	----	1.1	----	0.6	0.6	1.1	6.7	12
(4) Disagree	6.1	1.7	9.5	0.6	5.0	1.7	4.5	1.7	10.6	41.3	74
(5) Strongly disagree	----	----	1.1	0.6	3.9	----	1.7	----	0.6	7.8	14
(6) Don't know	----	----	----	----	----	----	----	----	0.6	0.6	1
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 55.4540; df = 45

h. Water Usage

More than half, 52.5%, feel that coal development will not use water needed for crops (Table 11-66). A large majority of the manual construction workers and mining personnel agree with this position. A majority of the ranchers and ranch hands disagree, contending that coal development would use water needed for crops.

Responses are less certain to the question of whether or not the removal of the coal seams may cause meadows to dry up and springs to disappear. The responses are divided between those agreeing (39.1%), those disagreeing (27.9%), and those neutral or undecided (33.0%). A large majority of the ranchers (76.8%) agree that these effects may result (Table 11-67).

i. Attitudes Toward Moratoriums

A series of questions asked respondents' attitudes toward moratoriums for a limited time on further leasing of coal lands, building of power plants, development of new strip mines, and construction of new railroads, power lines, or pipelines associated with coal development. From 38.5% to 48% favor the various types of moratoriums. Forty-eight percent favor a moratorium on the building of any more power plants in this area. From 36.3% to 45.8% oppose moratoriums. The moratorium on additional railroads, power lines, or pipelines associated with coal development is opposed by 48.5%. Of all respondents opposing moratoriums, at least 45% are employed in Colstrip. A majority, 51.2% of those employed in Colstrip oppose a moratorium on building more power plants. Of those working outside of Colstrip, 61.3% favor a moratorium on building more power plants in the study area (Table 11-68).

j. Police Services

A large majority of all respondents, 69.8%, feel that the study area is a very safe place to live (Table 11-69). Comments made by respondents indicate that many were comparing the study area to more urban areas. When asked if the police protection is of high caliber, 43.5% agreed that it is and 36.4% disagreed. The concern about police protection is more pronounced in Colstrip. Of those living in the construction trailer courts, two-thirds indicated that police protection is not of high caliber. Only two respondents out of the thirty living in these courts indicated that the police protection is of high caliber. On the permanent side of Colstrip, 42.1% indicated concern about police protection and 26.9% indicated satisfaction (Tables 11-70 and 11-71).

k. Influence on Local Government

When asked whether or not they are satisfied with their influence on local government, the respondents are almost equally divided between satisfied (34.6%), uncertain (34.1%), and unsatisfied (31.3%). More ranchers indicated dissatisfaction (42.8%) (Table 11-72). Of those respondents who had lived in the study area three years or less, a larger proportion (43.3%) indicated uncertainty. Several Colstrip respondents indicated that the question was not applicable because they felt that there is no government in Colstrip; there is no public body to act for them. In general, the county government was not

TABLE 11-66

Rosebud Study Area Residents' Perceptions of the Effect of Coal Development on Agricultural Water Supplies, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 99. Water that is needed for crops will be used up by coal development:											
(1) Strongly agree	----	----	0.6	----	3.9	0.6	0.6	----	0.6	6.1	11
(2) Agree	0.6	0.6	1.1	----	7.3	----	3.9	4.5	5.0	22.9	41
(3) Neutral	0.6	----	1.7	0.6	0.6	0.6	2.2	1.2	3.9	11.2	20
(4) Disagree	7.3	1.1	17.9	2.2	3.4	1.7	2.8	2.2	9.5	48.0	86
(5) Strongly disagree	0.6	0.6	1.1	1.1	----	----	----	----	1.1	4.5	8
(6) Don't know	----	1.1	1.1	----	1.7	----	----	0.6	2.8	7.3	13
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 105.7657; df = 45; p < .001

TABLE 11-67

Rosebud Study Area Residents' Perceptions of the Effect of Coal Seam Removal on Underground Water Supplies, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 103. The removal of the coal seams may cause meadows to dry up and springs to disappear:											
(1) Strongly agree	----	----	1.1	----	3.4	----	0.6	0.6	1.7	7.3	13
(2) Agree	2.8	----	2.8	1.1	9.5	0.6	4.5	2.8	7.8	31.8	57
(3) Neutral	2.2	0.6	5.6	----	1.1	1.1	2.8	2.3	6.1	21.8	39
(4) Disagree	3.4	1.1	10.6	2.8	0.6	0.6	1.7	2.2	3.9	26.8	48
(5) Strongly disagree	----	0.6	0.6	----	----	----	----	----	----	1.1	2
(6) Don't know	0.6	1.1	2.8	----	2.2	0.6	----	0.6	3.4	11.2	20
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 75.7190; df = 45; p < .01

TABLE 11-68

Attitudes of Rosebud Study Area Residents Toward a Moratorium on Power Plant Construction, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 38. How would you feel about a moratorium for a limited time on building any more power plants in this area?											
(1) Strongly favor	----	0.6	3.4	----	6.7	0.6	1.7	1.1	3.4	17.3	31
(2) Favor	2.8	----	3.9	0.6	7.3	0.6	5.0	1.7	8.9	30.7	55
(3) Neutral	1.7	0.6	2.2	----	1.1	0.6	1.1	2.3	4.5	14.0	25
(4) Opposed	3.4	1.7	10.1	1.7	1.7	0.6	1.7	3.4	5.6	29.6	53
(5) Strongly opposed	1.1	0.6	3.4	1.1	----	----	----	----	0.6	6.7	12
(6) Don't know	----	----	0.6	0.6	----	0.6	----	----	----	1.7	3
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 79.9973; df = 45; $p < .001$

TABLE 11-69

Rosebud Study Area Residents' Perceptions of Their Feelings
of Personal Safety, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 8. This is a very safe place to live:											
(1) Strongly agree	----	0.6	1.1	----	2.8	----	----	----	1.7	6.1	11
(2) Agree	5.0	1.7	12.3	3.4	7.8	1.7	6.1	7.9	17.9	63.7	114
(3) Neutral	1.7	0.6	1.7	----	1.7	----	1.1	----	0.6	7.3	13
(4) Disagree	2.2	0.6	5.6	0.6	4.5	1.1	1.1	0.6	2.2	18.4	33
(5) Strongly disagree	----	----	2.2	----	----	----	0.6	----	0.6	3.4	6
(6) Don't know	----	----	0.6	----	----	----	0.6	----	----	1.1	2
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 44.5197; df = 45

TABLE 11-70

Attitudes of Rosebud Study Area Residents Toward the Quality of Police Protection, by Occupational Category

	Occupational Category									
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 11. Police protection in this area is of high caliber:											
(1) Strongly agree	----	----	0.6	----	0.6	----	----	----	1.1	2.2	4
(2) Agree	3.9	----	3.4	0.6	8.4	0.6	6.1	6.7	11.7	41.3	74
(3) Neutral	1.1	1.7	2.8	0.6	2.8	0.6	1.7	0.6	4.5	16.2	29
(4) Disagree	3.4	1.7	10.6	2.2	3.4	1.1	1.1	0.6	5.0	29.1	52
(5) Strongly disagree	0.6	----	3.9	----	1.1	----	0.6	0.6	0.6	7.3	13
(6) Don't know	----	----	2.2	0.6	0.6	0.6	----	----	----	3.9	7
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 70.6583; df = 45; p < .01

TABLE 11-71

Attitudes of Rosebud Study Area Residents Toward the Quality of Police Protection, by Area of County

	Area of County								
	Forsyth, Rosebud	Rural, East Section	Rural, West Section	Colstrip, Power Plant Side	Colstrip, Permanent Side	Ashland Area	Birney Area	% of Total	N
Question 11. Police protection in this area is of high caliber:									
(1) Strongly agree	0.6	----	----	0.6	0.6	----	0.6	2.2	4
(2) Agree	30.2	1.1	2.8	0.6	3.3	0.6	2.8	41.3	74
(3) Neutral	6.1	0.6	1.1	2.8	2.8	1.7	1.1	16.2	29
(4) Disagree	10.6	----	1.7	8.4	4.4	3.4	0.6	29.1	52
(5) Strongly disagree	1.1	0.6	1.1	2.8	1.7	----	----	7.3	13
(6) Don't know	----	----	0.6	1.7	1.7	----	----	3.9	7
Total	48.6	2.2	7.3	16.8	14.5	5.6	5.0	100.0	
N	87	4	13	30	26	10	9		179

Chi Square = 75.9478; df = 40; p < .001

TABLE 11-72

Attitudes of Rosebud Study Area Residents Toward the Extent of Their Influence on Local Government, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 135. How satisfied are you with the influence you have on local government?											
(1) Very satisfied	----	0.6	----	----	----	----	----	0.6	1.7	2.8	5
(2) Satisfied	4.5	0.6	6.1	1.1	5.6	1.1	3.9	4.5	4.5	31.8	57
(3) Uncertain, neutral	1.7	0.6	7.3	1.7	3.9	----	5.0	2.2	10.1	32.4	58
(4) Unsatisfied	2.2	1.1	5.6	0.6	6.1	0.6	0.6	----	5.0	21.8	39
(5) Very unsatisfied	0.6	0.6	3.4	0.6	1.1	1.1	----	0.6	1.7	9.5	17
(9) Don't know	----	----	1.1	----	----	----	----	0.6	----	1.7	3
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 52.4505; df = 45

perceived as a substitute for a town government.

1. Living in the Area

Over half of the respondents selected "convenient location for job" and the "way of life," 57.5% and 52.5%, respectively, as being very important to their decision to live in the area. The "beauty of the area" (Table 11-73) and "the deep social roots" were selected as very important by 35.2% and 23.5%, respectively. However, over half, 66.7%, of those who have resided in the area longer than four years selected "beauty of the area" as very important or somewhat important. Over half, 62.0%, of those who have resided in the area longer than eight years listed "deep social roots" as being very important or somewhat important. These data strongly suggest that further research into the meaning and signficance of these concepts could be fruitful.

D. State-Wide Public Opinion Survey

1. Survey Description

During the week of August 26, 1974, the Energy Planning Division initiated a state-wide public opinion survey, designed to provide information concerning the Montana public's opinion of energy-related issues. A questionnaire was mailed to 2,200 Montana residents whose names were pulled at random by a computer from voter registrations, tax rolls, and telephone books. A follow-up letter was mailed to participants approximately two weeks (September 9, 1974) after questionnaire distribution.

The questionnaire was distributed in two versions. The length of the initial instrument necessitated splitting the questionnaire in two. Half of the 2,200 individuals in the selected sample were asked to complete Form A; the remainder were asked to fill in Form B. Form A consisted of 39 Likert-type items in which respondents were asked to evaluate how closely a given statement matched their own opinion using five response categories ranging from strongly agree to strongly disagree. Three questions asked respondents to rank items on an ordinal scale from one to five and six questions sought answers by short-answer fill-in-the-blank responses or by selecting an appropriate alternative from a list of possible choices. Fourteen demographic questions completed the questionnaire, seeking answers to such things as age, sex, education, occupation, etc. of the respondent.

Form B used a similar format and consisted of 15 Likert-type items, seven ordinal ranking scales, 16 short-answer fill-in-the-blank or select-an-alternative questions, and 14 demographic items. Thirty-eight questions used on Form A were repeated on Form B. In total, the survey asked for response to 62 content questions and 14 demographic questions.

The questionnaire probed opinion in five general areas. Five items asked for opinions concerning strip mining, eight questions dealt with attitudes toward high voltage electric transmission lines, and 16 questions were directed toward an assessment of opinion in regard to coal-burning electric power plants. Twenty-two items probed opinions about living in Montana and attitudes toward energy development (possible alternatives for Montana) the industrialization of the state, and the perceived benefits and

TABLE 11-73

Attitudes of Rosebud Study Area Residents Toward the Importance of the Beauty of Their Area, by Occupational Category

	Occupational Category										
	Mining	Permanent Colstrip	Construction Manual	Construction Nonmanual	Rancher Ranch Hand	Railroad Employee	Government Employee	Retired	Business	% of Total	N
Question 232. [How important is] beauty of the area:											
(1) Very important	1.7	1.1	6.7	1.1	8.9	1.1	3.4	2.2	8.9	35.2	63
(2) Somewhat important	3.9	1.1	6.1	1.1	6.1	1.1	3.9	2.8	7.8	34.1	61
(3) Not very important	3.4	1.1	10.6	1.7	1.7	0.6	1.7	2.8	5.6	29.1	52
(9) No opinion	----	----	----	----	----	----	0.6	0.6	0.6	1.7	3
Total	8.9	3.4	23.5	3.9	16.8	2.8	9.5	8.4	22.9	100.0	
N	16	6	42	7	30	5	17	15	41		179

Chi Square = 40.2438; df = 18; p < .01

disadvantages associated with industrialization. Eleven questions examined attitudes toward agencies providing public information about the issues of coal development and electric utility construction in the state, as well as the perceived accuracy and quantity of information provided to the public. Copies of Forms A and B of the questionnaire are located in Appendix H3.

Prior to distributing the questionnaire to the state-wide public a pre-test of the instrument was conducted in the Helena area. A random sample of 100 was selected from the telephone directory. A pre-test response rate of 40% was achieved after a telephone follow-up. This figure was considered a probable rate of return for the larger, state-wide sample. The pre-test also suggested that modifications were needed in the questionnaire to clear up item ambiguity. Accordingly, changes in item content were completed before state-wide distribution.

Of the 2,200 questionnaires distributed to the public, 796 were returned. However, of this total 18 questionnaires were unusable because they were refused by the respondent, returned unanswered, or returned in mutilated form. An additional 34 questionnaires were returned by the Postal Service because the respondent had passed away, moved and left no forwarding address, or was otherwise unavailable. The 778 usable questionnaires reflect a response rate of 35.9%. However, this rate of response considers only those questionnaires received prior to mailing of the follow-up letter. Since that time approximately 150 additional questionnaires have been returned. The analysis of questionnaire results in this report considers only the 778 questionnaires received prior to the follow-up. An analysis of questionnaires received after the follow-up is presented in Appendix H4. Further results of the survey will be published in the final environmental impact statement on Colstrip Units 3 and 4.

2. Instructions for Reading Tables

The results of the public opinion survey are largely contained in a series of tables contained in the following discussion. The first set of tables reprints each questionnaire item with the percentage of respondents selecting each response category. Items that used the ordinal ranking scales are summarized by mean or average scores. The letter "N" or label "Total N" followed by a number indicates the total number of respondents that answered the question. Caution should be exercised in attempting to generalize the results of the survey to the population of Montana as a whole. As indicated in Table 11-74, questionnaire respondents were predominantly male, between the ages of 25 and 54, well-educated, with professional or technical occupations, and annual family incomes exceeding $10,000. While this particular pattern of questionnaire response limits generalization to the Montana public as a whole due to the relatively large numbers of respondents in these categories, one can safely assume that the questionnaire reflects an accurate picture of their attitudes. For example, the probability of error for the income category $0-$2,999 (N+20) is approximately ± 11%, however, for income category $15,000-$24,999 (N+208) the probability of error drops to approximately 0 ± 3.5%. Moreover, it is recognized that the affluent and well-educated tend to be the opinion leaders in

TABLE 11-74

MONTANA ENERGY SURVEY

SAMPLE DESCRIPTION

SEX

MALE	FEMALE	NOT SPECIFIED
73.7%	23.1%	3.2%

TOTAL N = 778

AGE

15 - 24 years	7.7%	55 - 64 years	11.4%
25 - 34 years	26.7%	65 - 74 years	3.3%
35 - 44 years	20.6%	75 or more years	1.3%
45 - 54 years	25.3%	Not Specified	3.6%

TOTAL N = 778

EDUCATION

3.5%	Elementary School (8 years or less)
4.6%	Some High School
17.1%	High School Graduate
25.8%	Some College
20.2%	College Graduate
25.7%	Graduate or Professional Training
3.1%	Not Specified

TOTAL N = 778

TABLE 11-74 (Cont.)

MONTANA ENERGY SURVEY

SAMPLE DESCRIPTION

OCCUPATION

33.7%	Professional, Technical, and Kindred Workers
9.4%	Business, Managers and Administrators
8.1%	Clerical and Sales Workers
5.3%	Craftsmen and Foremen
16.5%	Operatives and Services Workers
5.8%	Homemakers
7.2%	Agriculture; Farm Owners, Managers and Workers
4.5%	Retired
9.5%	Unemployed, Student, Occupation not specified.

TOTAL N = 778

NATIVE BORN MONTANAN

YES	NO	NOT SPECIFIED
19.3%	77.6%	3.1%

TOTAL N = 778

LENGTH OF RESIDENCE IN MONTANA

1.4%	Less than one year
27.3%	One - Five years
15.8%	Six - Ten years
11.4%	Eleven - Fifteen years
15.4%	Sixteen - Twenty-five years
25.9%	More than Twenty-five years
2.8%	Not Specified.

TOTAL N = 778

TABLE 11-74 (Cont.)

MONTANA ENERGY SURVEY

SAMPLE DESCRIPTION

RACE

Caucasian	American Indian	Other	Not Specified
94.5%	1.3%	0.8%	3.4%

TOTAL N = 778

POLITICAL AFFILIATION

Democrat	Republican	Independent	Other	Not Specified
27.9%	24.2%	38.4%	4.9%	4.6%

TOTAL N = 778

ANNUAL FAMILY INCOME

2.6%	Less than $2,999
5.0%	$3,000 - $4,999
9.3%	$5,000 - $6,999
13.8%	$7,000 - $9,999
26.2%	$10,000 -$14,999
26.7%	$15,000 -$24,999
11.3%	$25,000 plus
5.1%	Not Specified

TOTAL N = 778

TABLE 11-74 (Cont.)

MONTANA ENERGY SURVEY

SAMPLE DESCRIPTION

PLACE OF RESIDENCE

17.6%	City greater than 50,000 population
25.1%	City, population from 10,000 - 49,999
15.7%	City, population from 2,500 - 9,999
13.1%	City or town less than 2,499
16.8%	Rural - Farm or Ranch
5.3%	Suburban Lot
2.3%	Other
4.1%	Not Specified

TOTAL N = 778

LOCATION OF RIGHT-OF-WAY ON PROPERTY

YES	NO	NOT SPECIFIED
16.5%	74.0%	9.5%

TOTAL N = 778

TYPE OF RIGHT-OF-WAY

2.2%	Railroad
6.3%	Highway
5.9%	Pipeline
15.5%	Power Line

TOTAL N = 778

an urbanized society.

A second set of tables illustrates attitudes toward coal-fired power plants and electric transmission lines broken down by income category. (The transmission line tables and accompanying discussion are presented in Volume 4, Section 6.3.4.) Two sets of figures (both percentages) are illustrated in these tables. One number exhibits the raw percentage score for each response. A second figure, listed in parentheses, is an adjusted percentage which illustrates what the results would be if each income category were represented in the questionnaire results in proportion to its distrubution in the population at large. For example, respondents in income category $0-$2,999 make up 2.6% of the sample while 10.5% of the larger Montana population would fit this category. In like manner, respondents in income category $15,000-$24,999 make up 26.7% of the guestionnaire sample although they account for only 10.7% of the state population./75 The adjusted score results in a lowering of scores for groups overly represented in the sample and a raising of scores for those under represented.The adjustment procedure used in this analysis assumes that the distribution of scores will parallel those reported in the questionnaire results. This assumption is somewhat tenuous since the probability of error increases as the size of the subsample decreases (as in the case of the low-income category). Also, some respondents did not indicate their income category. Adjusted scores are not computed for this group. The number of individuals who failed to specify their income category is subtracted from the total number of respondents with adjusted percentages based on the adjusted total number of responses.

The final set of tables presents raw percentages computed by occupational category. These tables depict responses to selected items concerned with coal-fired power plants. Corresponding tables concerning high voltage electric transmission lines are presented in Volume 4, Section 6.3.4.

In reading the tables it is important to bear in mind that public opinion surveys measure opinion at one point in time. Duplication of the survey would most likely result in a shift in the scores presented. This is readily seen in pre-election political preference polls. Emphasis should not be placed on absolute scores. Rather the trend of opinion is the major factor to consider; the numbers readily change, but trends change more slowly.

3. Survey Results

a. Strip Mining

Five question examined attitudes toward strip mining. Table 11-75 illustrates the results. A majority of respondents (51.3%) indicated that strip mining was acceptable within the state. However, respondents suggested that strip mine operators be subject to some form of regulation (90.3%) and that strip mining is acceptable provided there are strong environmental safeguards to protect the land, air, water, and lifestyle of Montana residents (73.8%). Clear majorities also indicated that mining companies cannot be trusted to provide environmental safeguards unless compelled by law (83.9%) and that most respondents would prefer to live in areas other than those being strip mined (71.9%).

TABLE 11-75

Montana Energy Survey

Strip Mining

Strip mining should not be prohibited in Montana.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
14.2%	37.1%	11.8%	20.6%	15.4%

No Response 0.9%
Total N = 423

I favor the unrestricted strip mining of Montana coal.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
0.5%	3.1%	4.3%	24.1%	66.2%

No Response 1.9%
Total N = 423

Strip mining Montana's coal is acceptable if strong environmental safeguards are provided to protect the land, air, water and lifestyle of Montana residents.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
27.9%	45.9%	5.9%	11.6%	8.5%

No Response 0.2%
Total N = 423

The mining companies cannot be trusted to provide environmental safeguards unless compelled to do so by law.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
50.1%	33.8%	5.9%	6.4%	1.7%

No Response 2.1%
Total N = 423

I would prefer to live in an area without the presence of strip mining operations.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
50.3%	21.6%	15.4%	9.3%	2.8%

No Response 0.6%
Total N = 778

b. Power Plants

Attitudes toward coal-fired power plants were more negative than those illustrated in relation to transmission lines (compare tables in Volume 4, Section 6.3.4., with Tables 11-76 through 11-79). Respondents replied negatively to a question asking if they favored the construction of coal-fired power plants in Montana (52.0%). Approval of the power plants was indicated by 29.3%. Income groups earning greater than $10,000 per year were slightly more in favor of power plants than other groups (Table 11-80). Persons employed in agricultural occupations were the most negative (Table 11-81).

A clear majority (65.6%) expressed the desire not to live in an area where coal-fired power plants are located. Income did not appear to be a significant differentiating feature (Table 11-82) although respondents listing operative and service occupations appear slightly less concerned about living near power plants (Table 11-83).

Respondents modestly agreed with the idea that agriculture and power plants can co-exist in the same area (41.1%). However, the large neutral category (23.2%) could shift the balance of this question to those disagreeing (32.9%). Higher income categories are slightly more prone to suggest the co-existence of agriculture and power plants (Table 11-84).

An item suggesting that power plants be built at locations currently industrialized met with approval (50.8%). Respondents with annual incomes less than $10,000 per year were slightly more in favor of this idea than were respondents in the higher income brackets (Table 11-85). A clear majority (Table 11-86) indicated that power plant construction was acceptable provided strong environmental safeguards exist to protect the land, air, water, and lifestyle of Montana residents (59.6%).

Questions seeking opinions about who should pay the social and environmental costs associated with power plants were met with a mixed response. Respondents split on the idea of the consumers of electricity paying the costs with 47.7% approving, 40.0% disapproving, and 11.3% taking a neutral stance. The response pattern of this question is more understandable when one considers that most respondents are consumers of electricity, and, at present, this is perhaps the one area where most Montanans are directly touched by the issues of coal development and electric utility construction. Strong majorities suggested that the power companies pay the social and environmental costs associated with power plant construction (73.5%) and that the power companies pay these costs in advance (75.3%). Income level did not appear a significant differentiating factor on these items (Tables 11-87 and 11-88), though businessmen, managers, and administrators tend to disapprove the idea of pre-payment for environmental and social costs more strongly than others (Table 11-89).

The standard argument that industrial development lessens the tax load for the citizenry didn't carry much credence with the respondents—at least insofar as it applied to power plants. A clear majority (55.7%) disagree with the suggestion that tax relief comes in the form of

TABLE 11-76

Montana Energy Survey

Power Plant

I favor the construction of coal burning electric generating power plants in Montana.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
7.1%	22.2%	17.7%	23.2%	28.8%

No Response 0.9%
Total N = 423

I would have no objection to living in an area where coal burning electric power plants are located.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
4.9%	17.7%	10.9%	23.4%	42.2%

No Response 0.9%
Total N = 778

Coal burning electric power plants and agriculture can co-exist side-by-side in the same area.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
5.4%	35.7%	23.2%	18.7%	14.2%

No Response 2.8%
Total N = 423

If coal burning electric power plants are to be built in Montana, it is best to locate the plants in areas already used for industrial purposes.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
10.4%	40.4%	18.4%	24.8%	3.8%

No Response 2.1%
Total N = 423

Construction of coal burning electric power plants is acceptable if strong environmental safeguards are provided to protect the land, air, water, and lifestyle of Montana residents.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
21.3%	38.3%	8.5%	17.3%	13.0%

No Response 1.7%
Total N = 423

TABLE 11-77

Montana Energy Survey

Power Plant

The consumers of electricity should bear the social and environmental costs associated with the construction and operation of coal burning electric power plants.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
14.4%	33.3%	11.3%	25.1%	14.9%

No Response 0.9% Total N = 423

If a power company wishes to construct a coal burning electric power plant, it should not be required to pay the additional cost of providing schools, sewers, roads, recreational facilities, etc. in the area.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1.9%	13.2%	9.5%	31.4%	42.1%

No Response 1.9% Total N = 423

If a power company wishes to construct a coal burning power plant, it should be required to pre-pay the additional cost of providing schools, sewers, roads, recreational facilities, etc. in the area.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
32.9%	32.4%	15.8%	14.7%	2.4%

No Response 1.9% Total N = 423

The taxes generated by the construction and operation of power plants and electric transmission lines will result in a lessening of the tax load paid by other Montana citizens.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
4.8%	23.2%	14.8%	36.1%	19.6%

No Response 1.5% Total N = 777

Encouraging the construction and operation of power plants and electric transmission lines would be a wise step toward providing future generations of Montanans with job opportunities.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
7.5%	31.2%	16.0%	27.7%	16.1%

No Response 1.5% Total N = 777

TABLE 11-78

Montana Energy Survey

Power Plant

I oppose the construction of coal burning electric power plants in Montana when the electricity is largely shipped to other states.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
45.7%	24.3%	7.1%	15.8%	5.8%

No Response 1.3%
Total N = 778

If Montana coal is needed for the generation of electricity, the coal should be transported to the areas where the electricity is needed.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
27.0%	33.6%	13.7%	18.4%	5.9%

No Response 1.4%
Total N = 423

Coal burning electric power plants should be built in the areas where the electric power will be consumed.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
24.6%	33.6%	15.6%	20.9%	3.6%

No Response 1.6%
Total N = 422

Montana needs the electricity from the proposed coal burning electric generating plants to be located at Colstrip, Montana.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
6.6%	26.2%	23.2%	28.6%	13.2%

No Response 2.1%
Total N = 423

If additional coal burning electric power plants are built at Colstrip, Montana, I would expect electric rates to:

19.2%	Decrease
33.3%	Stay about the same
29.1%	Increase
9.9%	I wouldn't be affected because I receive electricity from a company that is not involved with the Colstrip project.
4.2%	Undecided
0.3%	I don't have electricity.

No Response 4.0%
Total N = 354

TABLE 11-79

Montana Energy Survey

Power Plant

If you were asked to select a location within Montana where the construction and operation of a coal burning electric power plant would do the most good and least harm, where would you locate such a plant? (Name a town, city, or county.)

Ten Most Frequently Listed Counties	First Choice	Second Choice	Total
1. Rosebud	164	47	211
2. Silver Bow	53	22	75
3. Yellowstone	42	27	69
4. Cascade	19	32	51
5. Custer	15	18	33
6. Deer Lodge	13	15	28
7. Powder River	8	16	24
8. Lewis & Clark	12	11	23
9. Carter	11	8	19
10. Garfield	8	10	18

Question:
I favor the construction of coal burning electric generating power plants in Montana.

TABLE 11-80

MONTANA ENERGY SURVEY

Income Category

	$0 to $2,999	$3,000 to $4,999	$5,000 to $6,999	$7,000 to $9,999	$10,000 to $14,999	$15,000 to $24,999	$25,000 plus	Income Level Not Specified	Total
Strongly Agree	0.0 (0.0)	0.0 (0.0)	0.7 (1.0)	0.9 (1.7)	1.7 (1.5)	1.7 (0.7)	1.4 (0.2)	0.7	7.1 (5.1)
Agree	0.5 (2.0)	0.7 (1.7)	0.9 (1.5)	2.4 (4.0)	7.3 (6.5)	6.4 (2.7)	3.3 (1.0)	0.7	22.2 (19.4)
Neutral	0.2 (1.0)	0.9 (2.2)	1.2 (1.7)	2.8 (5.0)	5.2 (4.5)	4.5 (2.0)	1.4 (0.2)	1.4	17.7 (16.6)
Disagree	0.7 (3.2)	1.2 (3.0)	3.3 (5.0)	3.5 (6.0)	6.4 (5.5)	5.2 (2.2)	2.4 (0.7)	0.5	23.2 (25.6)
Strongly Disagree	0.9 (4.2)	1.9 (4.5)	3.5 (5.5)	4.5 (7.7)	7.8 (6.7)	6.4 (2.7)	2.4 (0.7)	1.4	28.8 (32.0)
No Response	0.0 (0.0)	0.0 (0.0)	0.2 (0.5)	0.0 (0.0)	0.2 (0.2)	0.2 (0.2)	0.0 (0.0)	0.2	0.9 (0.9)
Total	2.4 (10.4)	4.7 (11.4)	9.9 (15.2)	14.2 (24.4)	28.6 (24.9)	24.3 (10.6)	10.9 (2.8)	5.0	100.0 (99.7)

N = 423
Adjusted N = 402
Top Figure a Raw Percentage
Figure in Parentheses an Adjusted Percentage

Question:
I favor the construction of coal burning electric generating power plants in Montana.

TABLE 11-81

MONTANA ENERGY SURVEY

Occupational Category	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	No Response	Total
Professional, Technical and Kindred Workers	0.9	6.4	5.4	8.7	12.8	0.0	34.3
Business, Managers, and Administrators	1.4	2.8	1.9	2.6	1.7	0.0	10.4
Sales and Clerical Workers	0.5	1.4	2.1	1.9	2.1	0.0	8.0
Craftsmen, Foremen and Kindred Workers	1.2	2.4	0.2	0.9	1.4	0.2	6.4
Operatives and Service Workers	0.7	4.7	2.8	2.4	3.3	0.2	14.2
Homemakers	0.2	1.2	0.7	1.9	1.9	0.2	6.1
Agriculture, Farm Owners, Managers, and Workers	0.2	0.5	1.9	0.9	2.4	0.0	5.9
Retired	0.7	1.4	0.9	1.2	1.2	0.0	5.4
Unemployed, Students, and Occupational not Specified	1.2	1.4	1.7	2.6	2.1	0.2	9.2
Total	7.1	22.2	17.7	23.2	28.8	0.9	100.0

N= 423
Figures are Raw Percentages

Question:
I would have no objection to living in an area where coal burning electric power plants are located.

TABLE 11-82

MONTANA ENERGY SURVEY

Income Category

	$0 to $2,999	$3,000 to $4,999	$5,000 to $6,999	$7,000 to $9,999	$10,000 to $14,999	$15,000 to $24,999	$25,000 plus	Income Level Not Specified	Total
Strongly Agree	0.0 (0.0)	0.0 (0.0)	0.1 (0.3)	0.4 (0.7)	1.3 (1.2)	2.1 (0.8)	0.6 (0.1)	0.4	4.9 (3.1)
Agree	0.4 (1.6)	0.5 (1.2)	1.0 (1.6)	1.8 (3.3)	5.1 (4.9)	5.1 (2.0)	2.8 (0.7)	0.9	17.7 (15.3)
Neutral	0.4 (1.6)	0.5 (1.2)	1.0 (1.6)	1.7 (3.0)	3.0 (2.8)	2.7 (1.1)	1.0 (0.3)	0.6	10.9 (11.6)
Disagree	0.0 (0.0)	1.3 (3.0)	2.7 (4.3)	3.0 (5.1)	6.6 (6.1)	6.6 (2.6)	2.4 (0.7)	0.9	23.4 (21.8)
Strongly Disagree	1.8 (7.3)	2.7 (6.2)	4.2 (6.9)	7.0 (12.3)	10.2 (9.6)	10.2 (4.1)	4.0 (1.1)	2.2	42.2 (47.5)
No Response	0.0 (0.0)	0.0 (0.0)	0.1 (0.3)	0.0 (0.0)	0.1 (0.1)	0.1 (0.0)	0.4 (0.1)	0.1	0.9 (0.5)
Total	2.6 (10.5)	5.0 (11.6)	9.1 (15.0)	13.9 (24.4)	26.3 (24.7)	26.8 (10.6)	11.2 (3.0)	5.1	100.0 (99.8)

N = 778
Adjusted N = 738
Top Figure a Raw Percentage
Figure in Parentheses an Adjusted Percentage

Question:

I would have no objection to living in an area where coal burning electric power plants are located.

TABLE 11-83

MONTANA ENERGY SURVEY

Occupational Category	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	No Response	Total
Professional, Technical and Kindred Workers	0.8	4.5	3.3	7.7	17.4	0.1	33.8
Business, Managers, and Administrators	0.6	1.8	1.7	2.2	3.0	0.1	9.4
Sales and Clerical Workers	0.1	1.5	0.9	2.4	3.1	0.0	8.0
Craftsmen, Foremen and Kindred Workers	0.6	1.4	1.0	0.5	1.5	0.1	5.1
Operatives and Service Workers	1.3	3.6	2.1	3.5	6.0	0.0	16.5
Homemakers	0.1	0.8	0.3	2.3	2.1	0.3	5.9
Agriculture, Farm Owners, Managers, and Workers	0.3	1.3	0.6	1.5	3.5	0.0	7.2
Retired	0.4	0.9	0.5	1.0	1.7	0.0	4.5
Unemployed, Students, and Occupational not Specified	0.6	1.8	0.5	2.2	4.0	0.3	9.4
Total	4.8	17.6	10.9	23.3	42.3	0.9	100.0

N= 777
Figures are Raw Percentages

Question:
Coal burning electric power plants and agriculture can co-exist side-by-side in the same area.

TABLE 11-84

MONTANA ENERGY SURVEY

Income Category

	$0 to $2,999	$3,000 to $4,999	$5,000 to $6,999	$7,000 to $9,999	$10,000 to $14,999	$15,000 to $24,999	$25,000 plus	Income Level Not Specified	Total
Strongly Agree	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.2 (0.5)	2.6 (2.2)	1.2 (0.5)	1.4 (0.5)	0.0	5.4 (3.7)
Agree	0.5 (2.0)	1.2 (3.0)	3.5 (5.5)	4.3 (7.2)	10.2 (9.0)	10.2 (4.5)	4.5 (1.2)	1.4	35.7 (32.4)
Neutral	0.5 (2.0)	0.9 (2.2)	2.4 (3.7)	3.5 (6.0)	6.6 (5.7)	6.1 (2.7)	1.9 (0.5)	1.2	23.2 (22.8)
Disagree	0.9 (4.2)	0.9 (2.2)	2.1 (3.2)	2.8 (5.0)	4.5 (4.0)	4.5 (2.0)	1.9 (0.5)	0.9	18.7 (21.1)
Strongly Disagree	0.2 (1.0)	1.4 (3.5)	1.7 (2.5)	2.4 (4.0)	4.3 (3.7)	2.4 (1.0)	1.2 (0.2)	0.7	14.2 (15.9)
No Response	0.2 (1.0)	0.2 (0.5)	0.2 (0.2)	0.9 (1.7)	0.5 (0.5)	0.0 (0.0)	0.0 (0.0)	0.7	2.8 (3.9)
Total	2.4 (10.2)	4.7 (11.4)	9.9 (15.1)	14.2 (24.4)	28.6 (25.1)	24.3 (10.7)	10.9 (2.9)	5.0	100.0 (99.8)

N = 423
Adjusted N = 402
Top Figure a Raw Percentage
Figure in Parentheses an Adjusted Percentage

Question:
If coal burning electric power plants are to be built in Montana, it is best to locate the plants in areas already used for industrial purposes.

TABLE 11-85

MONTANA ENERGY SURVEY

Income Category

	$0 to $2,999	$3,000 to $4,999	$5,000 to $6,999	$7,000 to $9,999	$10,000 to $14,999	$15,000 to $24,999	$25,000 plus	Income Level Not Specified	Total
Strongly Agree	0.5 (2.0)	1.4 (3.5)	0.5 (0.7)	1.9 (3.2)	1.9 (1.7)	3.1 (1.2)	0.7 (0.2)	0.5	10.4 (12.5)
Agree	1.7 (7.2)	1.9 (4.5)	4.5 (7.0)	7.3 (12.7)	13.2 (11.4)	6.6 (3.0)	3.8 (1.0)	1.4	40.4 (46.8)
Neutral	0.2 (1.0)	0.5 (1.2)	1.7 (2.5)	2.1 (3.7)	5.9 (5.3)	5.0 (2.2)	1.9 (0.5)	1.2	18.4 (16.4)
Disagree	0.0 (0.0)	0.2 (0.5)	2.1 (3.2)	2.1 (3.7)	6.4 (5.5)	9.0 (4.0)	4.0 (1.0)	0.9	24.8 (17.9)
Strongly Disagree	0.0 (0.0)	0.2 (0.5)	0.7 (1.0)	0.5 (0.7)	0.7 (0.5)	0.7 (0.2)	0.5 (0.2)	0.5	3.8 (3.1)
No Response	0.0 (0.0)	0.5 (1.2)	0.5 (0.7)	0.2 (0.5)	0.4 (0.5)	0.0 (0.0)	0.0 (0.0)	0.5	2.1 (2.9)
Total	2.4 (10.2)	4.7 (11.4)	9.9 (15.1)	14.2 (24.5)	28.6 (24.9)	24.3 (10.6)	10.9 (2.9)	5.0	100.0 (99.6)

N = 423
Adjusted N = 402
Top Figure a Raw Percentage
Figure in Parentheses an Adjusted Percentage

Question:
Construction of coal burning electric power plants is acceptable if strong environmental safeguards are provided to protect the land, air, water, and lifestyle of Montana residents.

TABLE 11-86

MONTANA ENERGY SURVEY

Income Category

	$0 to $2,999	$3,000 to $4,999	$5,000 to $6,999	$7,000 to $9,999	$10,000 to $14,999	$15,000 to $24,999	$25,000 plus	Income Level Not Specified	Total
Strongly Agree	0.5 (2.0)	0.2 (0.5)	2.1 (3.2)	2.4 (4.0)	7.8 (6.8)	4.5 (2.0)	2.8 (0.7)	0.9	21.3 (19.2)
Agree	0.2 (1.0)	2.4 (5.7)	3.3 (5.0)	6.1 (10.4)	9.5 (8.2)	10.6 (4.7)	4.5 (1.2)	1.7	38.3 (36.2)
Neutral	0.5 (2.0)	0.7 (1.7)	1.2 (1.7)	1.7 (2.7)	1.9 (1.7)	1.4 (0.7)	0.7 (0.2)	0.5	8.5 (10.7)
Disagree	0.7 (3.2)	0.5 (1.2)	1.7 (2.5)	0.9 (1.7)	5.9 (5.3)	4.7 (2.0)	2.1 (0.5)	0.7	17.3 (16.4)
Strongly Disagree	0.5 (2.0)	0.9 (2.2)	1.4 (2.2)	2.8 (5.0)	3.1 (2.7)	2.8 (1.2)	0.7 (0.2)	0.7	13.0 (15.5)
No Response	0.0 (0.0)	0.0 (0.0)	0.2 (0.5)	0.2 (0.5)	0.5 (0.5)	0.2 (0.0)	0.0 (0.0)	0.5	1.7 (1.5)
Total	2.4 (10.2)	4.7 (11.3)	9.9 (15.1)	14.2 (24.3)	28.6 (25.2)	24.3 (10.6)	10.9 (10.6)	5.0 (2.8)	100.0 (99.5)

N = 423
Adjusted N = 402
Top Figure a Raw Percentage
Figure in Parentheses an Adjusted Percentage

Question:
The consumers of electricity should bear the social and environmental costs associated with the construction and operation of coal burning electric power plants.

TABLE 11-87

MONTANA ENERGY SURVEY

Income Category

	$0 to $2,999	$3,000 to $4,999	$5,000 to $6,999	$7,000 to $9,999	$10,000 to $14,999	$15,000 to $24,999	$25,000 plus	Income Level Not Specified	Total
Strongly Agree	0.2 (1.0)	1.4 (3.5)	1.9 (2.8)	1.2 (2.0)	3.1 (2.7)	4.3 (1.7)	1.9 (0.5)	0.5	14.4 (14.2)
Agree	0.2 (1.0)	0.9 (2.2)	1.9 (2.8)	4.3 (7.2)	8.7 (7.7)	10.6 (4.7)	5.7 (1.5)	0.9	33.3 (27.1)
Neutral	0.7 (3.2)	0.0 (0.0)	2.1 (3.2)	1.4 (2.5)	4.5 (4.0)	1.7 (0.7)	0.2 (0.0)	0.7	11.3 (13.6)
Disagree	0.9 (4.2)	1.4 (3.5)	2.8 (4.2)	4.7 (8.2)	7.8 (6.7)	4.0 (1.7)	1.9 (0.5)	1.4	25.1 (29.0)
Strongly Disagree	0.2 (1.0)	0.9 (2.2)	1.2 (1.7)	2.4 (4.0)	4.0 (3.5)	3.8 (1.7)	1.2 (0.2)	1.2	14.9 (14.3)
No Response	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.2 (0.5)	0.5 (0.5)	0.0 (0.0)	0.0 (0.0)	0.2	0.9 (1.0)
Total	2.4 (10.4)	4.7 (11.4)	9.9 (14.7)	14.2 (24.4)	28.6 (25.1)	24.3 (10.5)	10.9 (2.7)	5.0	100.0 (99.2)

N = 423
Adjusted N = 402
Top Figure a Raw Percentage
Figure in Parentheses an Adjusted Percentage

Question:

If a power company wishes to construct a coal burning power plant, it should be required to prepay the additional cost of providing schools, sewers, roads, recreational facilities, etc. in the area.

TABLE 11-88

MONTANA ENERGY SURVEY

Income Category

	$0 to $2,999	$3,000 to $4,999	$5,000 to $6,999	$7,000 to $9,999	$10,000 to $14,999	$15,000 to $24,999	$25,000 plus	Income Level Not Specified	Total
Strongly Agree	0.7 (3.2)	2.1 (5.3)	4.0 (6.2)	4.5 (7.7)	9.2 (8.0)	7.1 (3.2)	2.8 (0.7)	2.4	32.9 (34.3)
Agree	0.7 (3.2)	1.9 (4.5)	2.6 (4.0)	3.8 (6.5)	10.9 (9.5)	8.5 (3.7)	3.1 (0.7)	0.9	32.4 (32.1)
Neutral	0.9 (4.2)	0.2 (0.5)	1.9 (2.7)	3.1 (5.3)	4.5 (4.0)	2.8 (1.2)	1.9 (0.5)	0.5	15.8 (18.4)
Disagree	0.0 (0.0)	0.5 (1.2)	1.2 (1.7)	1.4 (2.5)	3.3 (2.7)	5.4 (2.5)	2.4 (0.7)	0.5	14.7 (11.3)
Strongly Disagree	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.9 (1.7)	0.2 (0.2)	0.2 (0.0)	0.7 (0.2)	0.2	2.4 (2.1)
No Response	0.0 (0.0)	0.0 (0.0)	0.2 (0.2)	0.5 (0.7)	0.5 (0.5)	0.2 (0.0)	0.0 (0.0)	0.5	1.9 (1.4)
Total	2.4 (10.6)	4.7 (11.5)	9.9 (14.8)	14.2 (24.4)	28.6 (24.9)	24.3 (10.6)	10.9 (2.8)	5.0	100.0 (99.6)

N = 423
Adjusted N = 402
Top Figure a Raw Percentage
Figure in Parentheses an Adjusted Percentage

Question:

If a power company wishes to construct a coal burning power plant, it should be required to pre-pay the additonal cost of providing schools, sewers, roads, recreational facilities, etc. in the area.

TABLE 11-89

MONTANA ENERGY SURVEY

Occupational Category	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	No Response	Total
Professional, Technical and Kindred Workers	12.8	11.8	5.2	3.8	0.5	0.2	34.3
Business, Managers, and Administrators	2.6	2.6	1.2	3.3	0.7	0.0	10.4
Sales and Clerical Workers	1.9	2.6	2.1	1.2	0.0	0.2	8.0
Craftsmen, Foremen and Kindred Workers	2.4	2.1	0.2	1.4	0.2	0.0	6.4
Operatives and Service Workers	3.8	5.7	2.4	1.9	0.2	0.2	14.2
Homemakers	2.4	1.9	1.9	0.0	0.0	0.0	6.1
Agriculture, Farm Owners, Managers, and Workers	2.6	1.9	0.7	0.5	0.0	0.2	5.9
Retired	1.7	0.9	0.5	1.7	0.2	0.5	5.4
Unemployed, Students, and Occupational not Specified	2.8	2.8	1.7	0.9	0.5	0.5	9.2
Total	32.9	32.4	15.8	14.7	2.4	1.9	100.0

N= 423
Figures are Raw Percentages

utility construction. Respondents were split on the issue of whether power plant and utility construction is a wise step toward providing future generations of Montanans with job opportunities. Agreement was voiced by 38.7%, disagreement by 43.8%, with 16.0% holding a neutral position. The higher income groups are slightly more inclined to accept the idea that power plants reduce the citizens' tax load and that such facilities are a wise step in providing future generations with jobs (Table 11-90 and 11-91).

Respondent preferences with regard to alternatives for energy development were clearly expressed. Seventy percent (70.0%) opposed the construction of coal-fired power plants in Montana when the electricity is to be shipped elsewhere. Strong majorities suggested that if Montana coal is needed to generate electricity the coal should be transported to the requisite area (60.6%) and that power plants should be built in the areas where the electric power will be consumed (68.2%). The higher income groups were slightly more willing to allow power plants in the state with the electricity going elsewhere (Table 11-92). No significant differentiation is noted between income groups with regard to exporting coal or out-of-state power plant construction (Tables 11-93 and 11-94). Occupational groups were not differentiated in their propensity to suggest a coal export policy (Table 11-95).

Respondents generally split in their opinion of whether Montana needs the electricity from the proposed units at Colstrip. A slight edge is given to those who disagree (41.8%) although 32.8% saw a need for the units. Almost 25.0% of the respondents took a neutral position. Respondents in the higher income categories were slightly more prone to feel the proposed units would produce needed electricity (Table 11-96). The majority of respondents felt the additional Colstrip units would affect electrical rates. One third (33.3%) of the respondents suggested rates would stay about the same, 29.1% thought rates would increase, and 19.9% envisioned a decrease.

One of the most interesting questionnaire items asked the respondent to select a location within Montana where the operation of coal burning electric power plants would do the most good and least harm. Table 11-79 summarizes the scores for the 10 most frequently named counties./76 Of the 10 counties listed, six are located in or near the periphery of the coal deposits of the Fort Union Basin, including Rosebud County, the most frequently chosen county and site of current energy developments at Colstrip. Four counties (Silver Bow, Deer Lodge, Cascade, and Lewis and Clark) lie in the central and western portion of the state.

There are at least three ways to interpret these survey results. From a relatively positive perspective one can interpret the results as a desire to see industrial development either apportioned to the smaller agricultural counties where industrial development will strengthen local economies, or given to already industrialized counties where further industrialization would be compatible with the existing economic and social structure.

A second interpretation draws upon the sociological concept "definition of the situation."

Question:
The taxes generated by the construction and operation of power plants and electric transmission lines will result in a lessening of the tax load paid by other Montana citizens.

TABLE 11-90

MONTANA ENERGY SURVEY

Income Category

	$0 to $2,999	$3,000 to $4,999	$5,000 to $6,999	$7,000 to $9,999	$10,000 to $14,999	$15,000 to $24,999	$25,000 plus	Income Level Not Specified	Total
Strongly Agree	0.1 (0.5)	0.1 (0.3)	0.5 (0.8)	0.1 (0.3)	1.0 (0.9)	1.8 (0.7)	0.9 (0.3)	0.3	4.8 (3.8)
Agree	0.3 (1.1)	0.5 (1.2)	1.5 (2.4)	2.8 (5.0)	5.8 (5.4)	8.5 (3.4)	3.0 (0.8)	0.8	23.2 (19.3)
Neutral	0.9 (3.7)	0.9 (2.0)	1.8 (3.0)	2.0 (3.4)	4.0 (3.8)	3.2 (1.2)	1.5 (0.4)	0.5	14.8 (17.5)
Disagree	0.6 (2.7)	2.2 (5.0)	3.6 (5.8)	5.3 (9.3)	10.8 (10.2)	8.2 (3.3)	3.3 (0.8)	2.1	36.1 (37.1)
Strongly Disagree	0.6 (2.7)	1.2 (2.7)	1.7 (2.7)	3.3 (6.0)	4.0 (3.8)	5.0 (2.0)	2.6 (0.7)	1.2	19.6 (20.6)
No Response	0.0 (0.0)	0.1 (0.3)	0.1 (0.3)	0.3 (0.4)	0.6 (0.7)	0.1 (0.0)	0.0 (0.0)	0.3	1.5 (1.7)
Total	2.5 (10.7)	5.0 (11.5)	9.2 (15.0)	13.8 (24.4)	26.2 (24.8)	26.8 (10.6)	11.3 (3.0)	5.2	100.0 (100.0)

N = 777
Adjusted N = 738
Top Figure a Raw Percentage
Figure in Parentheses an Adjusted Percentage

Question:

Encouraging the construction and operation of power plants and electric transmission lines would be a wise step toward providing future generations of Montanans with job opportunities.

TABLE 11-91

MONTANA ENERGY SURVEY

Income Category

	$0 to $2,999	$3,000 to $4,999	$5,000 to $6,999	$7,000 to $9,999	$10,000 to $14,999	$15,000 to $24,999	$25,000 plus	Income Level Not Specified	Total
Strongly Agree	0.0 (0.0)	0.1 (0.3)	0.8 (1.2)	0.8 (1.4)	2.1 (1.9)	2.4 (0.9)	0.9 (0.3)	0.4	7.5 (6.0)
Agree	0.8 (3.1)	1.0 (2.4)	2.4 (3.9)	4.6 (8.1)	8.1 (7.7)	8.2 (3.2)	4.0 (1.1)	2.1	31.2 (29.5)
Neutral	0.1 (0.5)	1.0 (2.4)	1.4 (2.2)	1.6 (2.7)	4.5 (4.2)	5.0 (2.0)	1.8 (0.4)	0.6	16.0 (14.4)
Disagree	1.0 (4.2)	1.8 (4.2)	2.7 (4.3)	4.4 (7.7)	7.9 (7.5)	6.6 (2.6)	2.3 (0.7)	1.0	27.7 (31.2)
Strongly Disagree	0.6 (2.5)	0.8 (1.8)	1.9 (3.1)	2.3 (4.1)	3.2 (3.1)	4.2 (1.8)	2.3 (0.7)	0.8	16.1 (17.1)
No Response	0.0 (0.0)	0.1 (0.3)	0.1 (0.3)	0.1 (0.3)	0.6 (0.5)	0.3 (0.1)	0.0 (0.0)	0.3	1.5 (1.5)
Total	2.5 (10.3)	4.8 (11.4)	9.3 (15.0)	13.8 (24.3)	26.4 (24.9)	26.7 (10.6)	11.3 (3.2)	5.2	100.0 (99.7)

N = 777
Adjusted N = 737
Top Figure a Raw Percentage
Figure in Parentheses an Adjusted Percentage

Question:
I oppose the construction of coal burning electric power plants in Montana when the electricity is largely shipped to other states.

TABLE 11-92

MONTANA ENERGY SURVEY

Income Category

	$0 to $2,999	$3,000 to $4,999	$5,000 to $6,999	$7,000 to $9,999	$10,000 to $14,999	$15,000 to $24,999	$25,000 plus	Income Level Not Specified	Total
Strongly Agree	1.5 (6.4)	2.8 (6.5)	4.2 (6.9)	7.1 (12.6)	12.5 (11.8)	10.5 (4.2)	4.5 (1.2)	2.6	45.7 (49.6)
Agree	0.8 (3.1)	1.4 (3.3)	2.7 (4.3)	3.2 (5.7)	6.7 (6.4)	6.2 (2.4)	2.4 (0.7)	0.9	24.3 (25.9)
Neutral	0.0 (0.0)	0.0 (0.0)	1.1 (1.9)	1.0 (1.9)	2.2 (2.0)	2.1 (0.8)	0.6 (0.1)	0.1	7.1 (6.7)
Disagree	0.1 (0.5)	0.5 (1.2)	0.8 (1.2)	1.5 (2.7)	3.2 (3.1)	5.7 (2.3)	3.0 (0.8)	1.0	15.8 (11.8)
Strongly Disagree	0.1 (0.5)	0.3 (0.5)	0.1 (0.3)	0.6 (1.1)	1.4 (1.4)	2.2 (0.8)	0.8 (0.1)	0.3	5.8 (4.7)
No Response	0.0 (0.0)	0.0 (0.0)	0.3 (0.4)	0.3 (0.4)	0.3 (0.3)	0.1 (0.0)	0.0 (0.0)	0.3	1.3 (1.1)
Total	2.5 (10.5)	5.0 (11.5)	9.2 (15.0)	13.7 (24.4)	26.3 (25.0)	26.8 (10.5)	11.3 (2.9)	5.2	100.0 (99.8)

N = 778
Adjusted N = 738
Top Figure a Raw Percentage
Figure in Parentheses an Adjusted Percentage

Question:
If Montana coal is needed for the generation of electricity, the coal should be transported to the areas where the electricity is needed.

TABLE 11-93

MONTANA ENERGY SURVEY

Income Category

	$0 to $2,999	$3,000 to $4,999	$5,000 to $6,999	$7,000 to $9,999	$10,000 to $14,999	$15,000 to $24,999	$25,000 plus	Income Level Not Specified	Total
Strongly Agree	0.7 (3.2)	1.7 (4.0)	3.1 (4.7)	3.3 (5.7)	6.4 (5.5)	6.9 (3.0)	3.1 (0.7)	1.9	27.0 (26.8)
Agree	0.9 (4.2)	1.7 (4.0)	4.7 (7.2)	5.7 (9.7)	10.6 (9.2)	6.4 (2.7)	2.8 (0.7)	0.7	33.6 (37.7)
Neutral	0.2 (1.0)	0.7 (1.7)	0.5 (0.7)	2.4 (4.0)	4.0 (3.5)	3.8 (1.7)	1.2 (0.2)	0.9	13.7 (12.8)
Disagree	0.2 (1.0)	0.5 (1.2)	0.9 (1.5)	0.9 (1.7)	5.9 (5.2)	5.4 (2.5)	3.8 (1.0)	0.7	18.4 (14.1)
Strongly Disagree	0.2 (1.0)	0.2 (0.5)	0.5 (0.7)	1.4 (2.5)	1.7 (1.5)	1.7 (0.7)	0.0 (0.0)	0.2	5.9 (6.9)
No Response	0.0 (0.0)	0.0 (0.0)	0.2 (0.2)	0.5 (0.7)	0.0 (0.0)	0.2 (0.0)	0.0 (0.0)	0.5	1.4 (0.9)
Total	2.4 (10.4)	4.7 (11.4)	9.9 (15.0)	14.2 (24.3)	28.6 (24.9)	24.3 (10.6)	10.9 (2.6)	5.0	100.0 (99.2)

N = 423
Adjusted N = 402
Top Figure a Raw Percentage
Figure in Parentheses an Adjusted Percentage

Question:
Coal burning electric power plants should be built in the areas where the elctric power will be consumed.

TABLE 11-94

MONTANA ENERGY SURVEY

Income Category

	$0 to $2,999	$3,000 to $4,999	$5,000 to $6,999	$7,000 to $9,999	$10,000 to $14,999	$15,000 to $24,999	$25,000 plus	Income Level Not Specified	Total
Strongly Agree	0.5 (2.0)	1.2 (2.8)	2.8 (4.2)	3.8 (6.8)	6.2 (5.3)	6.4 (2.8)	2.4 (0.7)	1.4	24.6 (24.6)
Agree	1.2 (5.3)	1.9 (4.5)	2.6 (4.0)	6.2 (10.7)	10.7 (9.2)	6.2 (2.8)	3.6 (1.0)	1.4	33.6 (37.5)
Neutral	0.2 (1.0)	1.2 (2.8)	2.8 (4.2)	0.9 (1.7)	4.0 (3.5)	4.7 (2.0)	0.9 (0.2)	0.7	15.6 (15.4)
Disagree	0.5 (2.0)	0.5 (1.7)	0.9 (1.5)	1.9 (3.2)	7.3 (6.2)	5.5 (2.5)	3.6 (1.0)	0.7	20.9 (18.1)
Strongly Disagree	0.0 (0.0)	0.0 (0.0)	0.5 (0.7)	0.7 (1.2)	0.5 (0.5)	1.2 (0.5)	0.5 (0.2)	0.2	3.6 (3.1)
No Response	0.0 (0.0)	0.0 (0.0)	0.2 (0.2)	0.5 (0.7)	0.0 (0.0)	0.4 (0.2)	0.0 (0.0)	0.5	1.6 (1.1)
Total	2.4 (10.3)	4.7 (11.8)	10.0 (14.8)	14.0 (24.3)	28.7 (24.7)	24.4 (10.8)	10.9 (3.1)	5.0	100.0 (99.8)

N = 422
Adjusted N = 401
Top Figure a Raw Percentage
Figure in Parentheses an Adjusted Percentage

Question:

If Montana coal is needed for the generation of electricity, the coal should be transported to the areas where the electricity is needed.

TABLE 11-95

MONTANA ENERGY SURVEY

Occupational Category	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree	No Response	Total
Professional, Technical and Kindred Workers	11.3	9.7	6.1	5.0	1.9	0.2	34.3
Business, Managers, and Administrators	2.1	2.8	1.2	3.8	0.5	0.0	10.4
Sales and Clerical Workers	1.9	2.1	1.7	1.9	0.5	0.0	8.0
Craftsmen, Foremen and Kindred Workers	1.9	2.6	0.2	1.2	0.5	0.0	6.4
Operatives and Service Workers	2.8	5.4	2.1	2.6	0.9	0.2	14.2
Homemakers	0.9	3.8	0.2	0.7	0.5	0.0	6.1
Agriculture, Farm Owners, Managers, and Workers	1.7	2.4	0.7	0.7	0.5	0.0	5.9
Retired	1.2	1.7	0.5	1.2	0.5	0.5	5.4
Unemployed, Students, and Occupational not Specified	3.1	3.1	0.9	1.4	0.2	0.5	9.2
Total	27.0	33.6	13.7	18.4	5.9	1.4	100.0

N= 423
Figures are Raw Percentages

Question:

Montana needs the electricity from the proposed coal burning electric generating plants to be located at Colstrip, Montana.

TABLE 11-96

MONTANA ENERGY SURVEY

Income Category

	$0 to $2,999	$3,000 to $4,999	$5,000 to $6,999	$7,000 to $9,999	$10,000 to $14,999	$15,000 to $24,999	$25,000 plus	Income Level Not Specified	Total
Strongly Agree	0.0 (0.0)	0.0 (0.0)	0.7 (1.0)	1.4 (2.5)	1.2 (1.0)	1.4 (0.7)	1.4 (0.5)	0.5	6.6 (5.7)
Agree	0.2 (1.0)	0.7 (1.7)	1.9 (3.0)	3.8 (6.5)	8.3 (7.2)	7.6 (3.2)	3.1 (0.7)	0.7	26.2 (23.3)
Neutral	1.2 (5.2)	1.2 (2.7)	2.4 (3.5)	2.6 (4.5)	6.6 (5.7)	5.2 (2.2)	2.4 (0.7)	1.7	23.2 (24.5)
Disagree	0.7 (3.2)	1.4 (3.5)	3.1 (4.7)	3.3 (5.7)	9.0 (7.7)	7.1 (3.2)	3.1 (0.7)	0.9	28.6 (28.7)
Strongly Disagree	0.2 (1.0)	1.4 (3.5)	1.9 (3.0)	2.1 (3.7)	3.1 (2.7)	2.8 (1.2)	0.9 (0.2)	0.7	13.2 (15.3)
No Response	0.0 (0.0)	0.0 (0.0)	0.0 (0.0)	0.9 (1.5)	0.5 (0.5)	0.2 (0.0)	0.0 (0.0)	0.5	2.1 (2.0)
Total	2.4 (10.4)	4.7 (11.4)	9.9 (15.2)	14.2 (24.4)	28.6 (24.8)	24.3 (10.5)	10.9 (2.8)	5.0	100.0 (99.5)

N = 423
Adjusted N = 402
Top Figure a Raw Percentage
Figure in Parentheses an Adjusted Percentage

This interpretation would imply that most citizens, relatively uninformed about what constitutes a "good" site for a power plant, leave the situation to the "experts" (e.g. power companies) to define. By selecting Colstrip for a power plant site, the "experts" have defined Rosebud and other counties in the Fort Union Basin as optimal sites for power plants. Following this interpretation, if a power company decided to locate its power plants elsewhere (provided the chosen site was not a "hands-off" area such as a national park), that site would be defined as the "best" location for a power plant. In other words, if a power company selected Augusta or Dillon for a power plant, most citizens would concur with that "definition of the situation."

A final, negative perspective views power plants as undesirable elements. By locating the plants in places such as Rosebud or Powder River counties, the undesireable features of power plants (e.g. pollution) are away from major populations. A number of respondents to the question of an optimal power plant site added remarks to their choice. This was particularly true when Silver Bow County (Butte) was listed. The general tenor of comment was "put the plant in Butte, the place is already a mess," (an obvious reference to the environmental degradation associated with 100 years of mining and smelting in the area).

It is difficult to gauge what interpretation reflects the sentiment of respondents. In all probability, all three perspectives are operative.

In summary, the general pattern of opinion reflects a desire to see that power plants are not built in Montana. Respondents express little desire to live in areas where power plants are located, and, if given alternatives to building power plants in the state, would prefer to see the plants located in areas where the electricity will be consumed with coal exported to those locales.

c. Industrial Development

Respondents indicate strong satisfaction with life in Montana (see Tables 11-97 through 11-103). Almost 75% of those polled indicate that they are willing to forego opportunities for higher income that could be earned elsewhere in order to live in Montana. A strong majority (62.6%) prefer to live in Montana as it currently is rather than risk damaging the state by further industrialization. However, respondents are almost evenly split on whether the industrial development of the state should be encouraged. Almost 43% suggest the encouragement of industrial development while another 43% oppose it. Of course, industrial development comes in many forms. Respondents indicated a preference for encouraging agriculture (non-industrial), wholesale and retail trade, recreation and tourism, and light industry such as textiles and clothing, printing and publishing. Heavy industry, mining, and the generation of electricity were much less preferred (Table 11-100).

Modest majorities concurred with the idea that promoting industrialization would enhance job prospects for future generations of Montanans (54.1%) and that further industrialization should be directed to areas currently industrialized

TABLE 11-97

Montana Energy Survey

Industrial Development

In order to live in Montana, I am willing to pass by opportunities for potentially higher income that might be earned elsewhere.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
38.3%	35.9%	7.8%	12.1%	4.2%

No Response 1.7% Total N = 778

I prefer to live in Montana as it currently is rather than risk possibly damaging the State by further industrialization.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
37.8%	24.8%	8.7%	21.7%	5.9%

No Response 1.0% Total N = 778

The industrial development of Montana should be encouraged.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
13.6%	28.9%	13.5%	25.1%	17.9%

No Response 1.0% Total N = 778

One way of providing future generations of Montanans with job opportunities is to promote the industrialization of the state.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
12.3%	41.8%	13.2%	20.6%	10.6%

No Response 1.4% Total N = 423

If new industry is to be built in Montana, it should be directed to areas of the state that are already industrialized.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
16.8%	32.9%	16.8%	26.7%	5.4%

No Response 1.3% Total N = 778

TABLE 11-98

Montana Energy Survey

Industrial Development

The need for electricity will require injuring the beauty of an area by constructing and operating electric utilities.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
14.9%	32.4%	11.1%	31.9%	9.0%

No Response 0.7%　　Total N = 423

National energy needs can best be met by:
7.3% increasing strip mining in Montana
8.0% increasing the number of electric generating plants in Montana
4.4% individuals and families conserving energy
10.6% industry and commercial institutions conserving energy
43.2% developing alternative sources of energy such as the sun and wind
9.9% other (specify) ________________
No Response 16.6%　　Total N = 777

Assuming that Montana is obliged to help the rest of the nation to meet growing energy needs, there remains the question of the reasonable limits of Montana's obligation. That is, how much coal development in Montana is enough, how much is too much?
24.6% there should be no further development; what we have under way is enough
32.6% further development should be confined to mining and exporting coal
20.8% further development should be confined to mining and mine-mouth coal burning electric power plants
11.7% further development should not be restricted, but should be a direct response to what the rest of the nation says it wants
No Response 10.3%　　Total N = 778

In general, and as a rule, who should pay the local economic costs of industrialization of coal resources such as expansion of law enforcement, public health, education services, etc.?
23.9% industry
4.4% local government
2.3% state government
2.4% federal government
21.1% the people who directly benefit from the energy produced
33.3% all of the above
2.1% none of the above (indicate who should pay in this case) ________________
No Response 10.5%　　Total N = 778

TABLE 11-99

Montana Energy Survey

Industrial Development

Would you be willing to accept a new industry into the area in which you live even if that industry might create or add to the pollution of the land, air or water?

( ) Yes	( ) No	( ) Undecided
22.5%	67.3%	6.5%
No Response 3.7%	Total N = 355	

If yes: How much of an increase in pollution would you be willing to accept beyond the existing conditions of your area?

Unlimited	Very Much	Quite a Bit	A Little	Undecided
2.0%	9.0%	17.0%	66.0%	6.0%
		Total N = 80		

Would you be willing to accept a new industry into the area in which you live even if that industry might result in an increase in population?

( ) Yes	( ) No	( ) Undecided
56.1%	33.2%	8.5%
No Response 2.3%	Total N = 355	

If yes: How much of an increase in population would you be willing to accept beyond the existing conditions of your area?

Unlimited	Very Much	Quite a Bit	A Little	Undecided
8.0%	8.0%	34.2%	46.7%	3.0%
		Total N = 199		

TABLE 11-100

Montana Energy Survey

Industrial Development

Again, using the 5 point scale rank the following list of industries according to your opinion as to their desirability to have located or expanded in Montana. (Put a number in each blank space)

Less Desirable				More Desirable
1	2	3	4	5

Total N	Mean Score		
332	2.82	a.	Underground mining
336	3.68	b.	Recreation and tourism
336	3.68	c.	Light industry such as textiles and clothing, printing and publishing, etc.
329	1.90	d.	Strip mining
340	3.44	e.	Food processing such as slaughterhouses, flour mills, canneries, etc.
335	2.04	f.	Heavy industry such as smelting, sawmills, oil refining, metal fabricating, etc.
334	2.69	g.	Generation and transmission of electricity
334	3.73	h.	Wholesale and retail trade
337	4.37	i.	Agriculture
334	3.37	j.	Transportation
		k.	Other (specify) ____________________

Rank the following list of potential industrial facilities according to your opinion of their desirability within Montana. (Put a number in each blank space)

Less Desirable				More Desirable
1	2	3	4	5

Total N	Mean Score		
311	2.42	a.	High voltage electric transmission lines.
314	2.07	b.	Coal fired electric power plants
314	1.80	c.	Strip mining
315	2.01	d.	High voltage transmission lines and coal fired power plants.
313	1.84	e.	High voltage transmission lines and strip mining.
312	1.77	f.	Coal fired power plants and strip mining.
310	1.75	g.	High voltage transmission lines, coal fired power plants, and strip mining.
143	3.60	h.	None of the above

TABLE 11-101

Montana Energy Survey

Industrial Development

Below is a list of potentially adverse features which might be expected to accompany the construction and operation of strip mines, coal burning electric power plants, and high voltage electric transmission lines. Rank each of the items based on your opinion as to how adverse such an event would be should it occur. (Put a number in each blank space)

Less adverse				More adverse
1	2	3	4	5

Total N	Mean Score		
333	2.82	a.	A potential increase in crime and other forms of deviant behavior.
334	3.35	b.	A potential population increase.
337	4.11	c.	A potential increase in the pollution of land, air, and water.
329	3.18	d.	A potential for cost of living increases.
335	3.61	e.	A potential for the loss of water from agricultural to industrial use.
338	3.73	f.	A potential increase in health hazards to man, animals, and plants.
332	3.34	g.	A potential loss of or damage to existing recreational facilities.
328	2.19	h.	A potential breakdown of friendship and family ties.
331	3.10	i.	A potential for increases in taxation to owners of residential, commercial, and agricultural property.
332	3.45	j.	A potential loss of agricultural land to industrial use.
326	3.52	k.	A potential overcrowding of educational facilities.
326	2.38	l.	A potential for damage to existing transportation facilities.
333	3.21	m.	A potential overcrowding of housing facilities.
316	2.30	n.	A potential for damage to the established business community.
		o.	Other (specify) ________________________________

TABLE 11-102

MONTANA ENERGY SURVEY

INDUSTRIAL DEVELOPMENT

Below is a list of potentially beneficial features which might be expected to accompany the construction and operation of strip mines, coal burning electric power plants, and high voltage electric transmission lines. Rank each of the items based on your opinion as to how beneficial such an event would be should it occur. (Put a number in each blank space).

Less beneficial — More beneficial

1 2 3 4 5

TOTAL N	MEAN SCORE	
329	2.23	a. A potential population increase.
334	2.96	b. A potential improvement in educational facilities.
335	2.59	c. A potential improvement in recreational facilities.
331	2.58	d. A potential opportunity to meet new people.
330	3.00	e. A potential for improvement in shopping and professional services.
337	3.50	f. A potential increase in job opportunities.
337	3.09	g. A potential increase in tax revenues.
329	2.59	h. A potential for improvement in social and cultural facilities.
335	2.49	i. A potential improvement in housing facilities.
331	2.61	j. A potential improvement in transportation facilities.
332	2.76	k. A potential improvement in opportunities for capital investment.
335	3.26	l. A potential contribution to industrial growth and energy self-sufficiency for the United States.
335	2.72	m. A potential to attract more industry to the area.
328	3.09	n. A potential for broadening the economic base of Montana.
		o. Other (specify) ________________

TABLE 11-103

MONTANA ENERGY SURVEY

INDUSTRIAL DEVELOPMENT

On the whole, do the potential beneficial features of coal development and the construction and operation of electric utilities equal the potential adverse features?

27.0% Yes	55.2% No	11.5% Undecided

No Response 6.2%   TOTAL N = 355

A	Do the potential beneficial features outweigh the potential adverse features	A	Do the potential adverse features outweigh the potential beneficial features?
	11.2% Yes 88.8% No		88.8% Yes 11.2% No
	TOTAL N = 196		TOTAL N = 196
IF YES:		IF YES:	
B	How much do the potential beneficial features outweigh the potential adverse features?	B	How much do the potential adverse features outweigh the potential beneficial features?
	40.9% Very much 40.9% Quite a bit 13.6% A little 4.6% Undecided		48.8% Very much 29.3% Quite a bit 2.3% A little 1.7% Undecided
			17.8% No Response
	TOTAL N = 22		TOTAL N = 143

(49.7%). A strong majority (67.3%) indicated they would not be willing to accept new industry in their area if it meant increases in pollution. Of those who were willing to accept new industry in their area, 66.0% attached the condition that pollution levels be increased only "a little." Most respondents (56.1%), however, indicated a willingness to accept new industry even if that industry led to local increases in population. However, those willing to see population increased desired small to moderate population growth (80.9%).

The trend observed throughout this analysis is again evident in Table 11-100. That is, respondents were most negative toward strip - mining, less so with power plants, and still somewhat less so with transmission facilities (see Volume 4, Section 6.3.4.). However, stripping coal for export is the preferred alternative to Montana energy development vis a vis electric utility construction. This trend is partially explained by reviewing Montana's history. Many Montanans have had an opportunity to see the impact of surface mining, primarily at Butte, but also in the Montana coal fields. Few Montanans have experienced the impacts of coal-fired power plants (most Montana electricity is produced in hydroelectric plants) or high voltage transmission lines (to date one 500 KV line cuts across a small segment in western Montana from Hot Springs to the Idaho border). Also, strip mining has been a national focal point of attention for a number of years and considerably more information has been generated concerning this issue. As more information and experience is gained with coal-fired power plants and transmission lines, Montana attitudes will shift. Just what direction this shift will take is open to speculation.

Two tables, 11-101 and 11-102, indicate ratings for various features (positive and negative) that might be expected to accompany the industrialization of Montana coal resources. In general, items considered potentially adverse were ranked higher than potentially beneficial features. This indicates a trend that respondents consider industrialization of coal resources more of a detriment than a benefit to the state or local communities. Adverse features given high scores were the potential for increased pollution, potential increases in health hazards, a potential for loss of water from agricultural to industrial use, and a potential overcrowding of educational facilities.

The item which received the lowest ranking as a potential adverse feature of coal industrialization was listed as a potential breakdown of family and friendship ties. As is evident in the ethnographic report conducted in Rosebud County, a breakdown of family and friendship ties, particularly friendship ties, is one of the most devastating and important social impacts associated with rapid industrialization. That people across the state rate this item low is not unexpected. It is a sociological truism that certain elements of life are "taken-for-granted realities." That is, people do not expect industrial booms such as that at Colstrip to influence long-standing, deeply personal family and friendship ties. Rather, they look past their own personal relationships and focus on external, tangible items such as overcrowded schools. While the latter are important concerns, they are also features which can be mediated or corrected in a relatively rapid manner. Strains put on family and friendship bonds are deeply felt and not quickly overcome.

Respondents saw the main benefits attached to the industrialization of coal resources as a potential increase in job opportunities, a potential contribution to industrial development and energy self-sufficiency for the United States, a potential increase in tax revenues, and a potential for broadening the economic base of Montana. A majority of the respondents indicated that the adverse features of coal-related industrial developments outweighed the potential benefits very much (48.8%) or quite a bit (29.3%) (Table 11-103).

In summary, respondents indicated a general satisfaction with life in Montana as it currently exists. Industrial development is to be considered, but the emphasis should be on developing industries such as tourism and recreation, light industry, and commerce as well as stimulating agriculture. Little preference was indicated for developing the heavy or extractive industries such as mining or the generation of electricity. Most respondents felt that the industrialization of Montana coal resources would be more detrimental than beneficial.

d. Public Information

A clear majority of respondents indicated that they were very interested in the issues of coal development and electric utility construction in Montana (77.9%) (see Tables 11-104, 11-105, and 11-106). Almost 55% of the respondents considered themselves well-informed about such issues; close to 43% indicated that they had read, heard, or seen more than 11 news articles, broadcasts, documentaries, or programs relating to coal development and utility construction within the past six months. While the respondents indicated that they felt well-informed about such issues, 74.5% perceived that the Montana public as a whole was largely uninformed.

Respondents indicated that newspapers and television were their most frequently used channels of public information. Approximately 57% of the respondents suggested that not much information concerning the issues of coal development and electric utility construction is being made available to the general public. Organizations cited as providing the most (quantity) of information were environmental groups, the news media, power companies, and state government agencies. A modest majority of respondents indicated that the information received concerning energy development in the state was not accurate (46.8%). However, the neutral category absorbs 34.5% of the responses to this question. Perceptions of informational accuracy are closely tied to the organization disseminating the information. Environmental groups, the news media, citizens groups, and state government agencies received higher accuracy scores than others. Mining and power companies received the lowest scores for informational accuracy. Almost 65% of the respondents indicated distrust of some organization providing information about Montana energy development. Of those reporting distrust, 49.9% indicated distrust of power companies, 19.0% the mining companies, 13.2% environmental groups, and 6.6% state government agencies. The major reason cited for distrusting mining and power companies was their vested interest in the situation. Distrust of environmental groups was usually indicated by some comment such as "they are too far out," "haven't got any common sense" or a

TABLE 11-104

MONTANA ENERGY SURVEY

PUBLIC INFORMATION

I am very interested in the issues of coal development and the construction of electric utilities in Montana.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
37.3%	40.6%	12.1%	4.9%	4.2%

NO RESPONSE 0.9% TOTAL N = 778

I consider myself well informed about the issues of coal development and electric utility construction in Montana.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
13.0%	41.8%	20.3%	21.3%	3.1%

NO RESPONSE 0.5% TOTAL N = 778

How many news articles, broadcasts, documentaries, or programs have you seen, heard, or read in the past six months dealing with Montana coal development and electric utility construction?

None	1-5	6-10	11-15	16 or more
3.5%	25.1%	26.9%	14.9%	27.8%

NO RESPONSE 1.8% TOTAL N = 773

Most people in Montana are well informed about the issues of coal development and electric utility construction.

TABLE 11-104 (cont.)

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
0.7%	9.5%	14.2%	55.6%	18.9%

NO RESPONSE 1.2%   TOTAL N = 423

Below is a list of possible sources of information. Using the 5 point scale rank these sources according to how frequently you use them to receive information concerning coal development and electric utility construction in Montana. (Put a number in each blank space.)

Seldom				Often
1	2	3	4	5

TOTAL N	MEAN SCORE	
718	2.94	a. Conversation with other people
708	2.70	b. Magazines
714	2.75	c. Radio
684	1.79	d. Public Meetings
720	3.25	e. Television
727	3.75	f. News papers
		g. Other (specify)____________________

TABLE 11-105

MONTANA ENERGY SURVEY

PUBLIC INFORMATION

Not much information concerning coal development and the construction of electric utilities in Montana is being made available to the general public.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
14.9%	42.2%	13.9%	23.9%	4.1%

No Response 0.9%   TOTAL N = 777

Rank the items below in terms of how much (not accuracy) information you believe these organizations provide the general public concerning the issues of coal development and electric utility construction. (Put a number in each blank space.)

Less Information				More Information
1	2	3	4	5

TOTAL N	MEAN SCORE		
721	2.22	a.	Federal Government Agencies
729	2.72	b.	State Government Agencies
731	3.05	c.	Power Companies
723	3.68	d.	Environmental Groups
695	1.76	e.	Labor Unions
715	2.62	f.	Citizens Groups
712	2.36	g.	Mining Companies
704	1.93	h.	Local Government Agencies
722	3.33	i.	The News Media (excluding news releases from other organizations)
		j.	Other (specify) ____________________

TABLE 11-106

MONTANA ENERGY SURVEY

PUBLIC INFORMATION

By and large, the information the Montana public receives concerning the issues of coal development and electric utility construction within the state is accurate.

Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
1.4%	15.1%	34.5%	36.4%	9.9%

No Response 2.1% TOTAL N = 423

Again, using the 5 point scale rank the organizations based on your opinion of the accuracy of the information they make available to the public. (Put a number in each blank space.)

Less Accurate				More Accurate
1	2	3	4	5

TOTAL N	MEAN SCORE	
697	2.94	a. Citizens Groups
676	2.06	b. Labor Unions
709	2.75	c. Federal Government Agencies
693	2.67	d. Local Government Agencies
704	3.04	e. The News Media (excluding news releases from other organizations)
694	1.94	f. Mining Companies
709	2.06	g. Power Companies
710	3.06	h. Environmental Groups
706	2.90	i. State Government Agencies
		j. Other (specify) ____________________

Is there any type of organization which is providing information concerning coal development and electric utility construction in Montana that you distrust?

64.5% Yes 10.4% No 18.8% Undecided
No Response 6.3% TOTAL N = 777

TABLE 11-106 (cont.)

MONTANA ENERGY SURVEY

PUBLIC INFORMATION

If yes: What type of organization do you distrust? ______________________

Citizens Groups	3.8%
Labor Unions	1.4%
Federal Government Agencies	2.6%
Local Government Agencies	0.6%
The News Media	3.0%
Mining Companies	19.0%
Power Companies	49.9%
Environmental Groups	13.2%
State Government Agencies	6.6%

TOTAL N = 501

related statement which suggested that the respondent perceived environmental groups to be outside the mainstream of rational thought.

11.2.2.3. Impact on Community Services

The impact of Units 3 and 4 on social service delivery systems in Rosebud County is largely calculated on the basis of projected population increases (see Section 11.2.2.1.) within the county and its three municipalities (Forsyth, Colstrip, and Lame Deer). This method is used because impacts on social services are seen as emanating from service demands of the population. As the population increases, so does the demand for social services.

Projections of future social service needs are based on two alternative growth policies for the town of Colstrip. At present, the town is pursuing a policy of limited growth which, in many respects, leads to inefficient provision of services and wasteful commuting on the part of more workers than might wish to commute. Nevertheless, for a variety of reasons, it is unlikely that Western Energy or MPC will wish to define its growth policy more clearly without prodding from agencies of state or local government. If a free-growth policy were pursued at Colstrip, this might result in Forsyth's being undermined as a predominant service center in the area. If, on the other hand, a restricted growth policy is pursued, this might lead to satellite residential development on private land around Colstrip. By leaving the situation unresolved, local and county planners are prevented from being able to make clear projections about future service needs in the area. Clear land use policies and population growth policies must be developed before clear projections of the location of future service needs can be predicted. Nevertheless, some tentative projections of service needs are made for the county as a whole (Table 11-107). While basic service needs have been prepared for the illustrative population distribution model (Table 11-108), showing the service needs that might be associated with alternative growth policies for Colstrip, a general table of urban service needs (Table 11-109) per 1,000 of population is also presented so that readers can project the service needs in each category for whatever growth assumptions they want to make for each town. Table 11-110 presents estimated school-age population in Rosebud County to the year 2000.

A. Impact on Public Services

1. Health Care

a. Hospitals

Future hospital bed needs have been projected on the basis of national average bed needs. However, reliable projections cannot be made apart from the resolution of the problems of physician supply. If one assumes that physician supply difficulties will be resolved, the population forecast suggests the need to enlarge the county hospital by 1980. Because of the needs of temporary construction personnel (shown in parentheses in Table 11-107) construction of the additional twenty-bed wing on the Forsyth hospital should be started sooner than otherwise.

TABLE 11-107

PROJECTION OF ROSEBUD COUNTY SERVICE NEEDS

SERVICE	ACTUAL 1974[1]	PROJECTED NEEDS 1975	1978	1980	1985	1990	1995	2000
Doctors - Primary Care[4]	5[5]	6[2] (2)[3]	7(3)	7	8	8	9	10
Doctors - Specialty Care[6]	0	5 (1)	6(2)	6	7	7	7	8
Dentists[7]	1	4 (1)	4(2)	4	5	5	6	6
Hospital Beds[8]	26	29 (8)	34(13)	35(2)	38	41	45	49
Beds for Elderly[9,10]	39	27	27	27	27	28	27	27
Home Health Care Vists to the Elderly[10,11] (perweek)	NA[12]	120	120	121	122	126	126	120
Law Officers[13]	23[14]	14 (4)	17(7)	18(1)	19	20	22	25
Police Cars[15]	16[16]	4 (1)	4(2)	4	5	5	6	6
Sanitary Fill[17] (acres)	NA	29 (8)	24(13)	35(2)	38	41	45	49
Teachers and classrooms[18]	100[19]	117(35)	145(54)	150(8)	157	169	184	203

NA = Not Available
Footnotes for this table are on the following pages

Footnotes for Table 11-107

1) The services for 1974 are those which were actually provided. Service needs for all other years are based upon the population forecasts.

2) Figures have been rounded off to the nearest whole unit.

3) Figures for base needs of operating personnel, secondary service personnel, families and/or long-term residents appear outside parentheses. Figures for construction-related needs appear in parentheses.

4) Adequacy Standard: 1 Doctor: 1,222 population.
Source: Medical Economics Magazine, cited by Montana Department of Health and Environmental Science 1973.

5) This includes two Public Health Physicians assigned to the Northern Cheyenne Reservation.

6) Adequacy Standard: 1 Doctor: 1,508 population.
Source: Medical Economics Magazine, cited by Montana Department of Health and Environmental Science 1973.

7) Adequacy Standard: 1 Dentist: 2,000 population.
Source: U.S. Department of Agriculture, publication ERS 465, p.9.

8) Adequacy Standard: 4 beds: 1,000 population.
Source: Based on the national average of 1,183 patient-days per year per thousand of population multiplied by about 82% average occupancy rate for each hospital. These figures lead to a projected need of four hospital beds per thousand of population.

The projections of hospital bed needs do not consider a variety of variables which must be considered by local planners in projecting actual local hospital needs. Not considered are the following factors: the availability of other regional facilities, the frequency of need of local people to travel to larger hospitals which can provide more specialized services, the availability of doctors and other health care personnel at the local level, the availability of good ambulance and other patient transfer facilities, providing improved access to other regional medical facilities, and the desirability of building satellite ambulatory care centers in smaller cities and concentrating high quality in-patient services in the larger cities. These questions are beyond the scope of this study and need to be considered by comprehensive regional planning groups.

Projections include reservation population and therefore include hospital beds which will need to be provided on the reservations as well as those needed off the reservation. Since a clinic at Lame Deer on the Northern Cheyenne Reservation could possibly be built to serve non-Indian population, this could affect the utilization of other hospital facilities at Crow Agency, Forsyth, Miles City, and possibly even Billings and Sheridan, depending on the facility's capabilities.

9) Adequacy Standard: Based on Montana State minimum use rate of 9,116 patient days per year (1973) for patients over the age of 65 requiring skilled, personal or intermediate nursing.
Source: Montana State Department of Health and Environmental Sciences.

10) It is assumed that construction-related personnel and permanent operating, mining and services personnel associated with the mining and plant operations at Colstrip will not contain individuals over the age of 65.

11) Adequacy Standard: 2 visits per week to 10% of the population over 65.
Source: Montana State Department of Health and Environmental Sciences, Division of Comprehensive Health Planning, Home Health Care, January 1974. Cited by permission.

12) There is a public health nurse at Forsyth who visits the elderly although most of her time is spent handling other responsibilities.

13) Adequacy Standard: 1 Officer: 500 population.
Source: National and Wyoming averages, cited in Intermountain Planners and Werth-Berger Associates, Powder River Basin Capital Facilities Study for the Wyoming Department of Economic Planning and Development, p. 52.

14) This total includes two State Highway Patrolmen, an eleven-member Northern Cheyenne Tribal Police Force and a ten-member County Sheriff Department. The Sheriff's Department includes the Sheriff and Under Sheriff, four Deputies at Forsyth, two at Colstrip and one each at Birney and Ashland.

15) Adequacy Standard: 1 car: 2,000 population.
Source: National and Wyoming averages, cited in Intermountain Planners and Werth-Berger Associates, Powder River Basin Capital Facilities Study for the Wyoming Department of Economic Planning and Development, p 52. Standards range from 1 car: 2,000 population to 1 car: 3,000 population. Low population density of Rosebud County makes the former preferable.

16) This includes two State Highway Patrol cars, seven vehicles (six cars and one pick-up) for the Northern Cheyenne Tribal Police Force, and seven cars for the County Sheriff Department.

17) Adequacy Standard: 4 acres: 1,000 population.
Source: De Chiara, Joseph and Lee Koppelman, Planning Design Criteria, Van Nostrand Reinhold Company 1969, p. 320.

18) Adequacy Standard: 1 teacher: 18.2 children.
Source: GPO publication DHEW(OE) 73-11402 by Bettey Foster, cited in Intermountain Planners and Werth-Berger Associates. Powder River Basin Capital Facilities Study for the Wyoming Department of Economic Planning and Development, p 35.

It is assumed here that there will be one teacher per classroom, thus projected numbers of classrooms needed is the same as projected numbers of teachers needed. Because of the temporary nature of much of the population with the likelihood of temporary units being used, we have not attempted here to project space needs in permanent units, nor non-teaching school personnel needs.

Projections here assume that all those of school age will attend; this will probably not be the case; thus, the projections may be slightly inflated.

19) This is the total number of certified staff personnel employed by the school districts in the county, as listed in the 1973-74 Montana Education Directory, Superintendent of Public Instruction, Helena, MT.

TABLE 11-108

MUNICIPAL NEEDS BASED ON ILLUSTRATIVE[1] DISTRIBUTIONS OF PERMANENT ROSEBUD COUNTY POPULATIONS

Category of Service	Existing Facilities (1974)	Low Impact on Colstrip[2] - Year -		High Impact on Colstrip[3] - Year -	
		1980	1985	1980	1985
Water Supply[4] (hundreds of acre feet per year)					
Colstrip	6[5]	5	5	7	8
Forsyth	24[6]	5.6	7	4.6	5
Lame Deer	2[7]	2.4	3	2.4	2.6
Water Treatment[8] (millions of gallon per day)					
Colstrip	1.5	1.3	1.3	1.8	2.1
Forsyth	1.5	1.4	1.8	1.2	1.3
Lame Deer	.9	.6	.8	.6	.7
Lagoon Acreage[10]					
Colstrip	11	25	25	35	40
Forsyth	8	28	35	23	25
Lame Deer	10	12	15	12	13
Teachers & Classrooms[11]					
Colstrip	26[12]	41	41	58	66
Forsyth	34	46	58	38	41
Lame Deer	18[13]	20	25	20	21

Footnotes for this table are on the following page.

Footnotes for Table 11-108

1) These service projections are based on the illustrative permanent population distributions shown and explained in Section 11.2.2.1. of this report.

2) This alternative assumes: 1) that the Western Energy Company will limit the population of Colstrip to 2500 people, resulting in a high population increase at Forsyth and a moderate increase at Lame Deer; and 2) that out-migration from rural areas in the county will occur.

3) This alternative assumes: 1) that major coal-related population increases will be concentrated at Colstrip; 2) that moderate population increases will occur in Forsyth and Lame Deer; and 3) that out-migration from rural areas of the county will occur.

4) Adequacy Standard: .20 acre-feet per person per year.
Source: Wyoming State Engineer's Office, cited in Intermountain Planners and Werth-Berger Associates, Powder River Basin Capital Facilities Study for the Wyoming Department of Economic Planning and Development, p 31.

5) Based on a figure of 350 gallons per minute from 4 wells.

6) Based on a pumping capacity of 1,500 gallons per minute from the Yellowstone River to the treatment plant.

7) Based on a pumping capacity of 45 gallons per minute for each of three wells.

8) Adequacy Standard: 517.5 gallons per day per person.
Source: Wyoming State Engineer's Office, cited in Intermountain Planners and Werth-Berger Associates, Powder River Basin Capital Facilities Study for the Wyoming Department of Economic Planning and Development, p 31.

9) The water supply at Lame Deer is well-water that tests pure and does not require treatment.

10) Adequacy Standard: 1 acre per 100 population.
Source: Montana State Department of Health and Environmental Science.

11) Adequacy Standard: 1 teacher to 18.2 children.
Source: GPO publication DHEW (OE) 73-11402, by Bettey Foster, cited in Intermountain Planners and Werth-Berger Associates, Powder River Basin Capital Facilities Study for the Wyoming Department of Economic Planning and Development, p. 35.

It is assumed that there will be one teacher per classroom, thus projected numbers of classrooms needed is the same as projected numbers of teachers needed. Because of the temporary nature of much of the population, with the likelihood of temporary units being used, we have not attempted here to project space needs in permanent units, nor non-teaching school personnel needs.

These education needs have been computed on the assumption that 30% of the illustrative permanent population will be school age and will attend school.

12) These are the number of certified staff personnel employed by the school districts of Colstrip, Forsyth and Lame Deer, as reported in the 1973-74 Montana Education Directory.

13) Since Lame Deer does not have a high school, this figure represents only the number of certified staff in the existing grade school.

TABLE 11-109

RELATIONSHIP BETWEEN URBAN POPULATION LEVELS AND CONSEQUENT UTILITY SERVICE NEEDS

UTILITY NEEDS	500	1000	1500	2000	2500	3000	3500	4000	4500	5000	5500	6000
Water[1] (hundreds of acre feet per year)	1	2	3	4	5	6	7	8	9	10	11	12
Water Treatment[2] (millions of gallons per day)	.26	.52	.78	1.04	1.29	1.55	1.81	2.07	2.33	2.59	2.85	3.11
Sewage Treatment[3] (millions of gallons per day)	.08	.17	.25	.34	.42	.50	.59	.67	.76	.84	.92	1.01
Sewage Lagoon[4] (acres)	5	10	15	20	25	30	35	40	45	50	55	60

1. Adequacy Standard: .20 feet per person per year.
Source: Werth-Berger Associates 1974
2. Adequacy Standard: 517.5 gallons per day per person.
Source: Werth-Berger Associates 1974
3, Adequacy Standard: 168 gallons per day per person.
Source: Werth-Berger Associates 1974
4. Adequacy Standard: 1 acre per 100 population.
Source: HES 1974

TABLE 11-110

ESTIMATED SCHOOL AGE POPULATION (5-17) IN ROSEBUD COUNTY[1]

	1975	1978	1980	1985[2]	1990	1995	2000
Total[3]	2834	3623	2872	2850	3074	3357	3692
Base	950	2045	2135	2850	3074	3357	3692
Direct	263	594	594				
Construction	621	984	143				

[1] Estimates based on the assumption that school age children constitute 30% of the county base population. Estimates for construction and directly employed personnel are based on 1.125 school age children per married worker.

[2] For the years 1985-2000, children from the direct category are added to those of the base category.

[3] Projections of school needs located in Table 11-108 are drawn from these statistics.

Alternatively, improved systems of patient transfer to regional hospitals might be considered, especially if adequate ambulance service is available. In projecting future needs for health care facilities, we should perhaps doubt the possibility that Forsyth and Colstrip will be able to correct their present physician shortage considering the current difficulties of small towns in attracting doctors. And even if they do, citizen preferences for medical facilities in Billings and Miles City are not likely to be reduced rapidly. Two reasons for this can be foreseen. First, confidence in new doctors will grow slowly and, second, as population grows, the need for highly specialized medical services, such as Colstrip and Forsyth are not likely to attract, will grow also.

b. Ambulance Service

As was the case with the projection of future hospital bed needs, the future need for improved ambulance service depends at least partly on decisions about the location of hospital facilities and doctors. If a decision is made to give responsibility for most specialized medical care to the larger regional hospitals in Billings and Miles City, then perhaps the planners will want to recommend better ambulance service for the county than now exists. For example, ambulances could be equipped with radio facilities enabling patient condition to be monitored at the destination hospital throughout a journey. However, if such equipment is installed, more highly specialized ambulance attendants will be needed. Therefore, such equipment should be considered only if the county is prepared to hire full-time professional ambulance staff who work closely on a day-to-day basis with hospital personnel and who are well coordinated with these hospital personnel.

c. Retirement and Nursing Homes

As can be seen from Table 11-107, the present nursing home facility exceeds future needs as projected from national averages for nursing home bed needs. Possibly, low future needs projections result from excessively austere assumptions about increases in local population over the age of 65 during the next twenty-five years. Little growth in this age group is foreseen. Nevertheless, those who enter this age group may not wish to leave the county. Also, because of conditions resulting from rapid development and consequent social change, they may be more dependent on institutional facilities than otherwise might be the case. It is likely that a small retirement home or complex of retirement apartments for elderly couples should be provided in the county within the next few years.

Even though the present nursing facility is more than adequate according to national averages, it is currently operating at capacity and has no trouble filling spaces when they are available. This circumstance provides substantial qualification to the future nursing home bed need projections.

d. Public Health Nursing and Industrial Nursing

Although many citizens continue to view public health nursing as a service provided for the indigent, increasingly the service is being thought of by the nurses as a supplement to other available health care (especially in those places where physicians are scarce) or even as a preliminary step in the direction of a national health maintenance program. An increasing portion of the nurses' time is spent offering public clinics for immunization, child care, school health screening, family planning, and other basic health services needed by all citizens.

In Table 11-107, a category of home health care visits to the elderly is developed. If the adequacy standard used to develop this table is correct, at least two public health nurses are needed right now to visit elderly people. The adequacy standard states that 10% of the population over the age of 65 will need two home health care visits per week. Such an intensive need probably does not exist in Rosebud County at the present time inasmuch as needs for services often are not articulated until the service is available. People customarily just "make do." Possibly, if more home health visitation was available, the elderly would develop a sense of need for it.

As a result of the mandated regulations under the Occupational Safety and Health Act, as well as the desirability of providing good emergency services to workmen, high quality industrial nursing and ambulance services need to be maintained. Unusual types of accidents requiring specialized medical knowledge occur in thermo-generating plants. Also, methods of moving the injured workers in an industrial environment frequently require careful forethought and preparation. Therefore, at least one specialist in emergency industrial medical care will be needed at Colstrip to help plan appropriate service delivery systems to deal with this specialized need.

2. Mental Health

Like most similar programs, the Eastern Montana Mental Health Center, which serves a multi-county region from its headquarters in Miles City, exists largely as a result of federal grants. Consequently, the professionals involved tend to work more independently of the other service agencies than they might if they were subject to the same funding channels. Also, mental health staff personnel sometimes tend to see themselves as an elite among servcie providers. Such elitism may arise in part and indirectly from the stigma that is attached to the term "mental health" by many people.

In any case, mental health workers differ in their ability to overcome this stigma and in their ability to develop productive relationships, particularly with resistant potential clientele. Perhaps mental health services could be more effectively used by the public if they did not carry such a highly visible and negative label.

Through the service counselor in a human services center, specialists could be provided to meet needs without having to carry difficult and awkward labels. People might feel better if they could talk to a marriage counselor without feeling that their mental health were being examined. In times of turmoil, when individuals may be in great need of counseling services, the avoidance of unnecessary stumbling blocks is important. Although no firm adequacy standard has been developed for mental health services, it is clear that people do have difficulty with the adaptation processes that result from rapid population growth and social change. Therefore, we may be able to crudely project that if one counselor is needed in a county during stable times, perhaps two or even three are needed during unstable growth periods if only those needing aid could be identified and attended. However, clearly, at such times many people do not find access to the services they need.

Under present procedures, it must be left to local officials and citizens to seek whatever funds they feel they need to provide services in this category.

3. Social Services

a. County Welfare

If enabling legislation permitted, a centralized direction could be imposed over all welfare services. However, the organizational decisions might best be left to local leaders, perhaps utilizing state or federal consultants. Possibly the present county welfare director could assume enlarged responsibilities as director of all centralized services.

Beyond these structural considerations, no recommendations about specific future staff requirements are made. Not only should budget decisions affecting the employment of service delivery staff be subject to local priorities, but also, needs may be totally different during different stages of the boom-and-bust cycle. For example, in Campbell County, Wyoming, during the oil boom in the late sixties, welfare caseload went down while the need for a variety of other social services increased (Kohrs 1974). Decisions about the size of the needed service staff should be made after weighing all local needs and priorities, which are not always easy to assess clearly. Sometimes, real needs exist that are not felt by citizens. Frequently, a person who needs a service most is the last to realize and accept his need. This is a complex aspect of the decisions which must be made by human service agencies and by governmental leaders who want to meet both felt needs and real but unfelt needs.

b. Special Services

A number of special service needs that result particularly during times of rapid growth can be anticipated. During a period of social change, deviant behavior such as vandalism, rowdyism, drunkenness, and drug abuse become more common. Thus additional opportunities for people to obtain counseling and advocate representation may be necessary.

Similarly, special problems are caused for the elderly during rapid growth. It may be particularly important to develop programs which can help the elderly maintain high morale, a sense of community, and a sense of usefulness. Among the specific needs which should be borne in mind as programs are developed are the following: (1) transportation programs to help the elderly remain as mobile as they need to be;/77 (2) retired service volunteer programs to help elderly citizens find productive activities which are a benefit to the whole community; (3) clubs and recreation acitvities which enable the maintenance and strengthening of social relationships; (4) Meals-On-Wheels programs which enable the elderly to receive the benefits of health-maintaining nutrition without the financial cost of institutional care; and (5) consideration should be given to the construction of public housing projects for the elderly close to existing nursing home facilities. Again, this is a method of enabling senior citizens to achieve greater sense of security without increasing their institutional dependency.

Another concern which needs attention is the need for increased public discussion of the problems related to drug and alcohol abuse. Already the problems have arisen in the county as a result of increased use of both drugs and alcohol. Nothing suggests that these difficulties will not continue as growth continues. Therefore, people to carry on public education and counseling programs will continue to be needed. An important part of this process may involve bringing young people more fully into a sense of community with people of all ages in the county.

Alienation and the need to be a productive, appreciated member of the community can be a difficult problem among people of all ages during periods of social change. One of the services which can be valuable in helping to build a sense of community among new and old residents of the area is provided by the Cooperative Extension Service, a state-funded service administered through the Home Economics Department of the Montana State University. Community forums sponsored by the Extension Service can help build and maintain a sense of community and community dialogue about issues of local importance. Funding may need to be provided so that these activities can be expanded as continued growth impact is felt in Rosebud County. Perhaps particularly needed are extension agents trained in human and behavioral sciences who can assist local governmental officials in maintaining citizen participation in community concerns. However, many other extension activities requiring staff with other skills are also much valued.

4. Fire Protection

Inasmuch as fire fighting capacity in Rosebud County is limited at present, all fire fighting units within the county are especially in need of budget increases to effectively meet the needs of enlarged populations. In addition, substantial capital expenditure is needed to improve water systems to the level necessary to meet fire flow requirements. However, the Forsyth Fire Department, which is the best-equipped of the three town departments at present, should not project its future equipment needs until a clear growth policy for Colstrip is established. While none of the towns in Rosebud County are expected to grow to the size sufficient to support a professional fire fighting unit (at least not from the impact of the population growth caused by the construction and operation of generating facilities at Colstrip), reliable equipment; a good alarm and communications system; an adequately heated building; and a well-trained volunteer crew are necessary to provide minimally adequate protection.

Inasmuch as fire protection standards are a matter of community priority, with a wide range of different programs falling into broad adequacy standards, detailed specifications for future fire protection are not delineated in this report. Also, adequacy is assessed according to a quite complex formula./78 Further, no state or county authority can require that a privately owned company town establish fire protection services of a specified adequacy. In Forsyth, on the other hand, the State Fire Marshall may require certain specifications to be met for preservation of public safety.

Similar requirements are not upheld for rural fire protection services. As growth occurs in the county, as residential units begin to be constructed in outlying areas outside the jurisdiction of town fire departments, and as increased movement of railroad trains increases the danger of grass fires along railroad right-of-ways, improved county fire protection services will be necessary. The present arrangement which gives responsibility for rural fire protection to the Sheriff's Department is inadequate at present and will definitely be inadequate to future needs. The Sheriff and his deputies, already busy with law enforcement responsibilities, need to be relieved of fire protection duties. This work can more suitably be turned over to a county volunteer fire organization. Even though Montana law gives sheriffs the duties of county fire marshall, this does not require that they assume responsibilities as county fire chief also. In the future, it might be better for officials in each county to decide who should be county fire marshall, but that change will require revision of state law.

5. Law Enforcement

While the Rosebud County Sheriff's Department still has several problems to overcome before it is entirely adequate to meet current needs, the department's organizational structure should enable the provision of high-quality police services during future growth periods. Budget has already been allocated for a second deputy to be stationed at Colstrip, even though no town ordinances exist there for the deputies to enforce, and there is no authority to issue citations enforcing state traffic regulations since these do not apply on private property. At present, the legal staff of MPC is studying ways to overcome these shortcomings. Other problems which need to be solved by the department in the near future include the provision of office space, particularly for the justices of the peace, who, at present, must attempt to perform their duties in the same office as the Sheriff's staff. In addition, the present jail is located several blocks from the Sheriff's offices in the county courthouse. Unless someone is dispatched especially to guard prisoners in the jail, they remain unsupervised while serving their time. In view of this situation, the Sheriff's Department critically needs larger office facilities with a contiguous jail. As growth pressures continue, these needs will undoubtedly intensify.

To provide a sense of future need for law enforcement officers and police cars, Table 11-109 based on national averages per 1,000 of population, is included at the beginning of this section. These estimates could prove to be conservative if pressures for improved law enforcement continue as they have during the past year. The situation in Rosebud County during this year has been similar to that encountered during boom periods in both Campbell County and Sweetwater County, Wyoming. The crime index in both counties has increased markedly as a result of development activities. Thus, it may be necessary to provide more law officers than national averages prescribe, at least until plant construction is completed. Already law enforcement needs on the Northern Cheyenne Indian Reservation require many more officers than would be suggested by national adequacy standards.

6. Public Transportation, Highways, Roads, and Streets

Before 1980, considering the population impact of construction of Units 3 and 4, Rosebud County may have a sufficient traffic flow to justify regularly scheduled airline service. At present, airline service is not provided to any communities in the region as small as Forsyth, but possibly as a result of industrial activity, a larger demand for airline service will be generated in the future./79 As a result of improvements currently being made on the county airfield, it will be capable of handling small commercial aircraft whenever the airlines may wish to begin using it.

Improved bus service to Billings and Miles City might be appropriate as the population of Rosebud County grows. Train service, however, is not likely to increase because of added increments of local population inasmuch as train service responds mostly to transcontinental markets. Nevertheless, if the market for railroad travel increases in the nation as a whole and a sufficient number of passenger cars become available to provide this service, possibly local train service to Forsyth could be improved, regardless of immediate local need. Finally, depending upon population growth policies in the county, commuter bus services could be required for many years even after plant construction is completed.

While the condition of few roads in the entire state of Montana has aroused greater expresion of public concern than that of Route 315 which connects Colstrip to I-94 west of Forsyth, little other road work is apt to be needed in the county as a result of the construction of Units 3 and 4. Possibly, improvement of the same highway from Colstrip to Lame Deer should be considered, since Indian people may be commuting from Lame Deer to Colstrip for many years.

Perhaps, in the future, it would also be desirable to pave the road from Colstrip to Hardin, especially if a residential community is established near the Westmoreland mine site at Sarpy Creek. If this road is paved, some Colstrip residents might prefer to do their shopping in Hardin instead of Forsyth, especially if Colstrip is not offering a full range of commercial services by that date.

Aside from these roads, all other future construction of roads and streets might be within or immediately surrounding the towns of Colstrip, Forsyth, and Lame Deer. As growth occurs, the network of residential streets in all three places will need to be enlarged. However, the amount of paving required will depend upon land-use decisions affecting the density of population within these communities. If people live on five-acre ranchettes around the existing communities, a larger network of roads will be needed than if future housing is confined to small urban lots or to high-rise condominiums or apartments. Because much of the open land around Colstrip is slated for future strip-mining, the possibility of high density apartment housing in the community should not be overlooked./80

Until land-use and population growth policies are established within the county, no further projection of future road needs can be made. These details will need to be filled in by local planners in the future. This need underscores again the necessity for a sufficiently funded local planning organization.

7. Municipal Services

Since national adequacy standards are clearly defined for most municipal services, future needs, particularly for water and sewer systems, have been projected in Table 11-108. Beyond the provision of a sufficient supply of treated water and sufficient sewage treatment capacity, the need for pipelines to serve all residential areas is related to land-use planning and cannot be determined until residential distribution patterns and density have been decided. However, in general terms, it becomes more costly to provide urban services when houses are far apart from each other than when they are close together on small lots. Thus, density decisions can have an impact on future taxation patterns.

Inasmuch as sewage treatment plants are generally not economical for population concentrations of smaller than 10,000, no communities in Rosebud County are expected to require the construction of sewage treatment plants to replace existing lagoon systems as a result of population growth caused by the construction and operation of Units 3 and 4.

While the absence of storm drainage in Forsyth creates street maintenance problems at present, the current situation is not apt to grow any worse as a result of new growth in the community. The cost of constructing storm sewer systems in Forsyth will have to be weighed among other financial priorities in future years. It is likely that this need could be handled as part of a general street improvement program which may be carried forward in Forsyth in the future. Certainly, the maintenance cost associated with the existing street system will illustrate the desirability of having higher quality streets with storm drainage which is less costly to maintain over the long term.

Problems of garbage collection and trash handling do not seem to justify complex growth impact considerations. Given the amount of land which will need reclamation, it would seem that all generated garbage and trash could be easily and efficiently buried. Probably, additional trucks will be needed in the future in all communities if only because they wear out. If insufficient trash collection service is being provided, ordinary community grievance channels ought to enable the problems to be resolved. However, in Colstrip, at present, an orderly procedure for the airing of citizen grievances does not seem to exist. Since all citizens are directly or indirectly employed by MPC, they refrain from expressing their needs and desires, apparently for fear of losing their jobs, or aggravating an unfavorable reaction from the company.

8. Schools

Rosebud County would be in a better position to handle both present and future school growth pressures if a unified county-wide school district were established. Through such an administrative arrangement, resources could be deployed more equitably, both to maintain educational quality in all schools and to avoid the worst consequences of boom development in one particular area of the county. Even more important, consolidation of the school districts would enable the tax benefits of an industrial plant in one part of the county to be shared among all the schools. This could be important in enabling the maintenance of quality education in Forsyth in the future. While MPC's assets contribute to the tax base in the Colstrip School District, they make no contribution to the taxes which finance schools in Forsyth.

If Rosebud County could create a unified school system, it might be able to handle problems related to coal development more effectively than they have been handled up to this date. If the permit for the construction of Units 3 and 4 at Colstrip is granted, pressures on Colstrip and Forsyth schools are apt to continue. However, again, until growth policy is set for Colstrip, it is impossible to know how these pressures will be shared between the two communities. Table 11-108 at the beginning of this chapter gives an idea of what the situation might be under two alternative population distribution programs. Table 11-107 provides an idea of how the county-wide need for teachers and classrooms would grow in the county if the county population projections on which they are based are correct. If these projections are correct, it would seem apparent that more permanent classrooms are needed in the county than has been considered necessary up to this time. However, again, it must be borne in mind that the population projections used in this report include unspecified other coal development within the county.

Even if the population forecast and the teacher need projections are high, Western Energy's Project Manager for Colstrip has suggested that operating personnel needed for Units 1 and 2 will cause the population of Colstrip to stabilize near its present level (White 1974b). Inasmuch as this permanent population will likely have a larger proportion of school-age young people than is true of the present construction population, the present temporary school facilities in Colstrip could justifiably be replaced soon with a permanent new school building. Meanwhile, both the Colstrip and Forsyth school districts are having trouble making future plans until they know whether Units 3 and 4 will be constructed or not. If this decision is made in the affirmative, population distribution projections will be needed to enable the schools to prepare themselves for future needs far enough in advance to permit these needs to be effectively met.

Finally, pressures resulting from activities at Colstrip enable reconsideration of the long-standing desire of the Northern Cheyenne to have their own high school at Lame Deer. If this desire could be met, space would be opened in the Colstrip school for more new residents of that town without requiring construction of new facilities there. Further, a high school at Lame Deer would enable the structuring of a special curriculum for Indian students that could help the Cheyenne people maintain their culture in spite of threats presented by the prospect of widespread coal development and population increase in the surrounding area. While it has been assumed in the past that it is valuable for Indian students to be integrated with non-Indian students so that they can learn to adapt themselves to the dominant culture, the reverse could possibly be true. Some analysts suggest that ethnic sub-groups can adapt themselves to the dominant culture in a way that they think appropriate if they first obtain a firm grounding in their own culture. By building a high school for the Indian people at Lame Deer, growth pressures in other parts of the county could be relieved and shared more widely than they are at present. Further, in making this suggestion, it is assumed that the tribe could more easily obtain outside (possibly federal) funding for construction of a high school than taxpayers in the Colstrip School District could find outside funding for new school facilities in their district.

9. Recreation Facilities

Because decisions about the provision of recreation facilities spring more from community priorities than from national adequacy standards, it is difficult to firmly project each community's need. According to one standard (Montana Department of Fish and Game (1974a), ten acres of park land should be set aside for every thousand county inhabitants. However, it is infrequent that local officials use such a standard to direct their actions; more frequently, they seek expressions of community desire. Nevertheless, some general assessments are possible based upon patterns evolving in several counties in Montana and in neighboring states. In all the surveyed counties where coal development is occurring, few service concerns arouse greater public interest than those relating to the provision of a wider variety of recreational opportunities. Even in towns which are relatively well provided with recreational facilities, the public is interested in having an even greater variety than presently exists. These desires may reflect a trend toward a more recreationally-oriented lifestyle in the nation as a whole. Possibly the ever-greater variety of athletic events portrayed on television has increased public interest in a range of recreational activities. Perhaps this expression is so recent that political leaders have not yet had time to act on it. However, in some places, as they receive the flood of recreational wants, officials are asking whether desire for facilities is equivalent to need. Although this question indicates a search for budgetary guidelines, it is largely philosophical, inasmuch as the relationship between recreational facilities, quality of life, and general community welfare is largely unmeasurable.

The provision of recreational facilities may be one of the key issues related to the maintenance of an adequate quality of life at Colstrip. Under current employment conditions, MPC officials can restrict investment in recreational opportunities in Colstrip on the grounds that those who do not like it there can easily be replaced by other workers who are anxious to find employment. If this conception is correct, the company may have little interest in satisfying the recreational needs (as well as other service needs) of Colstrip residents, particularly the short-term construction employees./81 Further, they may believe that provision of facilities at Colstrip actually has much less to do with job turnover than other factors. However, over the long term, in the case of operational personnel, job turnover could prove costly for the company and could possibly be offset by the provision of facilities which make Colstrip an attractive place to live and remain. Though the relationship might become apparent through local manifestations of feeling, it is impossible to write an equation of tradeoffs between service facilities and job-turnover, but certainly current feelings on the part of community citizens as reflected in newspaper reports can give some sense of what these trade-offs might be./82

Similarly, in Colstrip and Forsyth, need for recreational facilities has to be reflected in community dialogue and political processes so that it may receive a priority in budget decisions. Information gathered in all the counties surveyed suggests highest citizen priority is placed upon recreation centers for young people, community swimming pools, and recreation facilities for senior citizens. Sometimes, however, citizens did not seem to have a clear picture of exactly what they would like to have until they had had some experiences to feed their imagination. For example, in Sheridan, Wyoming, which has the largest inventory of recreation facilities of any of the surveyed localities to be affected by coal development, citizens requested an even greater variety of facilities than their counterparts in other counties. One of the most highly valued facilities in Sheridan is a YMCA with indoor swimming pool, gymnasium, indoor track, handball and racquetball courts, steam bath, and other general use spaces for craft programs and other projects of civic interest. Apparently the success of this facility had fed citizens' imaginations as to what else might also be valuable. In some of the other counties surveyed, a tendency was discovered for some citizens to feel that recreational facilities available in local schools ought to be sufficient for the whole community if these facilities were made available to the entire community during evenings. However, upon further investigation, it was found that many schools are used in the evenings for school-related sports activities. In many cases, little time would be available for older citizens of the community to make use of school athletic facilities. In some cases, only those students active in interscholastic sports get to use school indoor athletic facilities except during gym periods. As a result, athletics, instead of being a participatory activity for a wide range of people, becomes a spectator activity for the majority.

Although greater effort could be made to make full use of the available facilities, it is clear that effective use of facilities requires program development, not simply a public announcement that facilities will be available. Often citizens are timid about taking advantage of an attractive opportunity if no one is able to facilitate their involvement and help them work into the program.

10. Planning

A need currently exists for an adequately funded local planning agency. A continuing role for planning agencies is foreseen in future years. These agencies cannot draw plans now and expect plans to take care of themselves later. As important as the preparation of plans is the task of implementing them and adjusting them to evolving contingencies. Full-time members of a Rosebud County planning staff need to be charged with this responsibility on a continuing basis both now and in the future. While no national adequacy standards have yet been established to enable the firm determination of just what type of planning agency the county and its localities need or how large a budget is needed to fund the required agencies, both officials and citizens are coming to understand the difficulties that can be avoided through planning. The next step is to find the funds to carry forward planning activities. Given other financial pressures, the availability of outside funds may prove to be essential to launch the necessary program.

B. Impact on Housing, Commercial Services, and Churches

According to the population forecasts in Section 11.2.2.1., Rosebud County could face a population increase of over 50% by 1980. The author of these forecasts notes that abstract forecasts themselves are less important than the coming problems indicated by the abstractions; and, as with all forecasts, there are a number of limitations which must be kept in mind. The expressed limitations of these forecasts support an argument that the impact of the development is not fully reflected in them. Indicating these limitations is not meant to disparage the forecasts--only to reaffirm their author's caveats.

The population forecasts do not reflect some of the rather rapid fluctuations which could occur in the near term. These fluctuations caused by such things as new contracts, contract completion, etc. could have profound impacts upon housing, commercial services, and churches in the area. For example, providing new housing or handling vacant housing on short notice could be a serious and dislocating problem. Likewise, a sizeable contract completion on top of an overstocked commercial inventory could produce significant cash-flow difficulties. Anticipating these problems depends upon the willingness of Western Energy and MPC to indicate well in advance the precise operation of their contracts to decision-makers and affected enterprises. Even then, the ability to anticipate fluctuation problems is somewhat speculative.

Further development prospects at the Westmoreland mine, the Birney-Decker area, and recent sales on the Northern Cheyenne Indian Reservation indicate that substantial development could occur in the vicinity of Rosebud County. The effect of such development on the forecasts is speculative.

Additionally, the projections do not include the workers at Units 1 and 2, nor do they reflect the number of people who might be attracted to Rosebud County and find no employment. A recent Billings Gazette article quoted the Montana Employment Security Commission to the effect that 300 to 400 people per week are inquiring about Colstrip employment, and 40 men per day arrived there looking for work (Billings Gazette 1974).

Finally, the forecasts may not adequately reflect the plant life costs that could accrue at the end of plant operation or at the time the plant's level of operation changes. One would expect some diminution of certain economic activities at that time. Failure to fully understand that somewhat distant period of activity could result in the imposition of some serious social costs that are not presently anticipated.

1. Housing

Providing housing for the projected numbers of newcomers to Rosebud County is a problem. Assuming about three and a half residents per housing unit, the requirements by 1980 could call for an additional 1,000 to 1,200 units in a county that in 1970 contained slightly more than 1,800 occupied units (U.S. Department of Commerce 1970a). Even accepting the assumption that 85% of the influx would reside in the county, some 850 to 1,000 units could be required.

The demand for about one-fifth to one-half of these new units—depending upon the year—comes from construction families who will presumably not remain in the county. The proposal in the Colstrip Plan to have 529 household units available in 1980 will not meet this influx. The shortfall will be in the neighborhood of 350 to 500 units, and considering the limitations of the forecasts, perhaps greater. Thus, 100 to 250 temporary units and a slightly larger number of permanent units will be needed—if the forecasts are valid and if the Colstrip Plan materializes. Providing sites for this number of housing units is in itself an enormous task.

As noted previously, housing for the aged could be a serious problem in Forsyth, particularly if the cost of living should rise significantly. The figures supplied for this study indicate a stable elderly population into the foreseeable future.

Without adequate funding, the Rosebud County Housing Authority, working primarily on subsidized housing for the elderly, will remain hamstrung. Adverse distribution effects—whatever their curent level—will thus be allowed to run their course, impacting most those people who are least able to pay.

Uncertainty exists about the best short-term and intermediate-term options for the residential expansion of Forsyth. A few feel that development across the Yellowstone River is a good alternative; others stress that such development would be a costly dispersion of the community and its service base. In the meantime, development pressures are mounting on the western and, more especially, on the eastern edges of Forsyth. Additionally, development is occurring and/or is planned on two rural drainages south of Forsyth.

It can also be predicted that with heightened coal development there will be an increasing demand for mobile-home living space in the area, notwithstanding the indicated preference for conventional residences expressed by some Colstrip residents (White 1974b). During the last four years there has already been a sizeable increase in the number of mobile homes located in Rosebud County (see Table 11-111 below). Tax assessment rolls from the Rosebud County assessor's office reveal the following number of mobile homes and trailer/campers in the county (the figures are not completely comparable because of yearly changes in category definitions):

Table 11-111

MOBILE HOME/TRAILERS/CAMPERS IN ROSEBUD COUNTY

Year	Mobile Homes	House Trailers/Campers
1971	206	58
1972	291	80
1973	375	159
1974	609	515

Source: Rosebud County Assessor's Office

One commentator, writing the DePaul Law Review, has enumerated some of the reasons for what he finds to be a nation-wide switch to mobile homes (Mrozek 1972). In 1961, mobile homes comprised only 8.4% of new single family housing starts; by 1965, that figure was 18.3%, and by 1969, that figure was 18.3%, and by 1969 it was 33.7%. In 1970, he notes, mobile homes constituted 95% of all single-family homes selling for less than %15,000, and 72% of those selling for less than $20,000. Additionally, as pointed out by the commentator: "the individual who simply anticipates a possible change in location in the not-too-distant future may feel considerably more secure assuming a seven-year mortgage, the usual term of a mobile home, than a twenty or thirty-year mortgage on a conventional home" (Mrozek 1972, p. 1009). The short-run criteria cited above, however, do indicate some rationale behind a movement toward movile home housing in construction and coal development areas.

The prospects of regulating adequately the siting of a large number of mobile homes in Rosebud County are dubious. Recently, a permit system was adopted for the town of Forsyth. However, no such system exists for the remainder of the county, and adopting one would be a complex affair./83

As noted, it is unlikely that the number of housing units of all kinds proposed in the Colstrip Plan will house the expected influx of population. Even if they would, however, a substantial number of incoming people simply may not wish to live in a company town. Additionally, some of the housing demand can be expected to occur at the site of secondary employment. This being the case, the shortfall of housing will probably extend beyond the immediate area of Colstrip.

2. Commercial Services

The development of commercial services can follow or precede housing development. Either way, a population increase of 50% by 1980 would predictably antagonize few businessmen outside agriculture. If the influx does not include a sizeable increment unable to find employment, consumptive businesses could experience about a 50% increase. However, projecting this level of increase for each business would assume no corresponding increase in the number of businesses, an unlikely prospect. As noted previously, the town of Colstrip is already taking steps to expand its very limited commercial sector. Additional enterprises can be expected to try out the coal boom, on an ad hoc basis, in and around Colstrip and Forsyth. Location of additional enterprises would probably be influenced by the anticipated settling and transportation patterns of the incoming population.

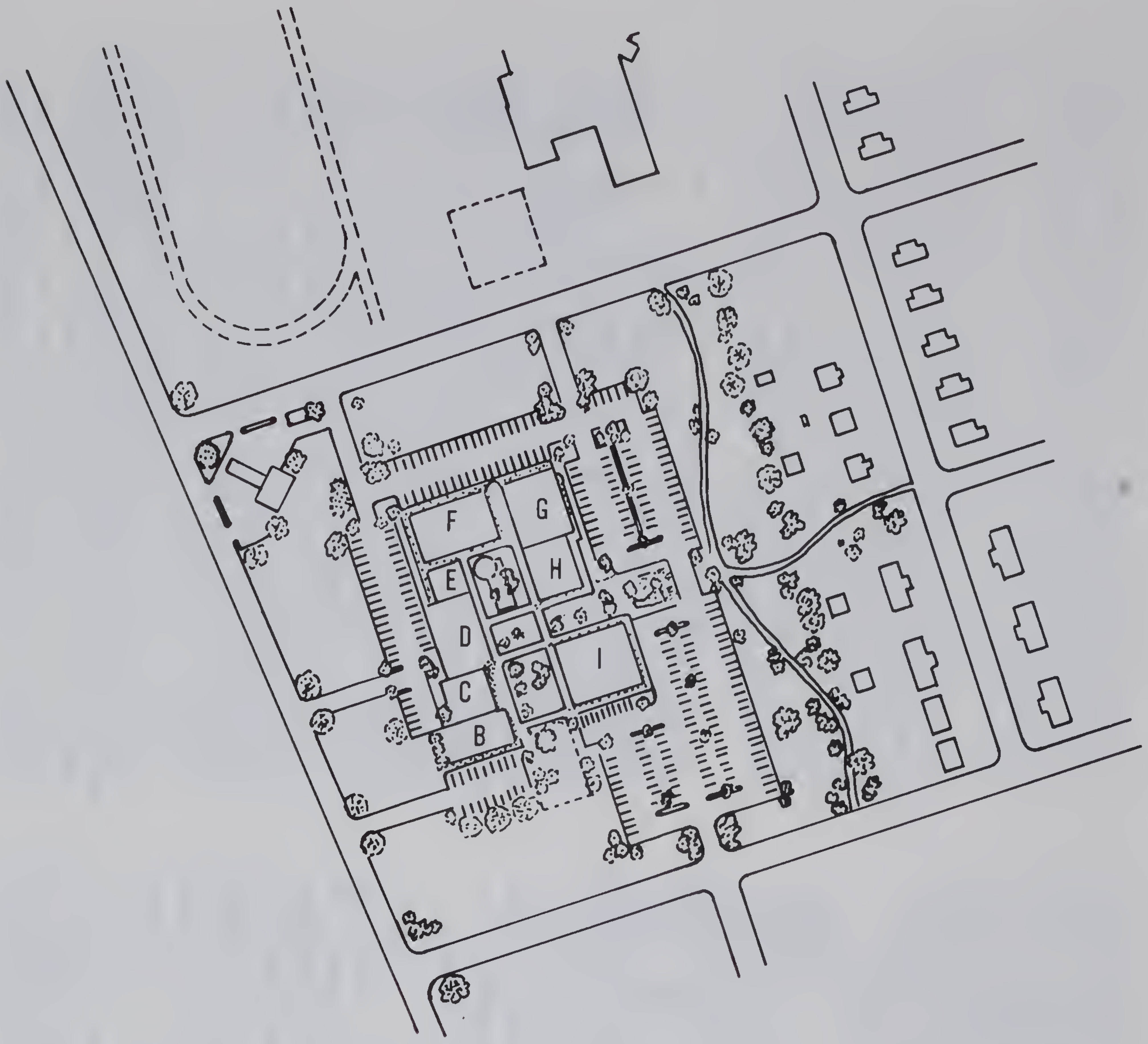
The Company Plan for Colstrip urges that "commercial development of Colstrip is necessary" (Ken R. White Company 1972). In addition, although commercial services at Colstrip are very limited, currently a major commercial center is under construction (see Figure 11-30). The Colstrip Plan recommends that commercial development should correspond with the expected population expansion and that a marketing analysis should be conducted to determine precise space requirements. However, the Plan does not discuss the responsibility of the Company, in undertaking a major profit-making venture such as a boom-town commercial complex, to assess the external effects of the center. For example, what effects will the commercial development in Colstrip have upon the business community of Forsyth?

The Plan proposes deed restrictions and development covenants for the control of the amount and quality of development within the town. However, such controls would not be effective against "mini-sprawl" development in areas adjacent to Colstrip, such as the restaurant 1½ miles north of Colstrip, which has recently added a trailer court and sales.

In regard to Forsyth, there appears to be considerable optimism in the commercial services sector; however, some of the expansion prospects are being received by local businessmen with uncertainty, even in the middle of a coal boom and the tourist season. One of the primary fears is that further expansion could result in additional competing private enterprises being attracted to Forsyth. An allied fear is that an increased population in Colstrip could attract even more businesses to locate there or nearby, thus depriving recently built-up businesses in Forsyth of customers. A third fear is that of "overbuilding" Forsyth's commercial sector. Should a bust or recession occur, it is not clear to local businessmen whether the long-time local businessmen or the newly attracted ones would survive.

Although the term "overbuilding" does come up frequently in interviews and conversations, nearly everyone interviewed looked only eight to ten years into the future as the long run. Little thought is being given to the prospects of Forsyth thirty-five years or more into the future. This deficiency is critical, since the cycle of an energy conversion complex is such that some of the most important costs could be experienced near the end of that thirty-five to forty-five year period, when the conversion plant's operation expires or changes substantially.

Given the existing, generally optimistic business climate in Forsyth, it is virtually certain that, despite reservations, substantial commercial and personal investments will continue to be made. At least one federally-insured business loan is being pursued currently, and an application for a bank charter is on file. It is likely that additional investments are being considered by interests in and out of Forsyth.



COMMERCIAL CENTER
Colstrip, Montana

A. Service Station (14,000 sq. ft.)
B. 20 Room Motel (3,825 sq. ft.)
C. Restaurant (2,025 sq. ft.)
D. General Office Space (3,375 sq. ft.)
E. Medical-Dental Office (1,089 sq. ft.)
F. Drug-Hardware Store (3,666 sq. ft.)
G. General Merchandise (3,575 sq. ft.)
H. Commercial Services (2,475 sq. ft.)
I. Grocery (4,875 sq. ft.)
J. Future Expansion (optional)

Design Features and Guidelines

Covered Walkways connecting commercial establishments.
Landscaped Open mall.
Mall features: pond for winter ice skating, benches, lights, kiosks, regulated signing.
Landscaped islands which break up expansive parking areas.
Clearly marked parking spaces (10' x 20') and vehicular circulation lanes (24 ft. wide)
Separate motel parking.
Bicycle path connecting commercial center with other areas of the town.
Facilities for parking and locking bicycles.
Planting buffer separating commercial center from residential area.
Highway advertising limited to one comprehensive, well designed sign.

(Ken R. White Company, 1972)

Without a complete knowledge of the acceleration, deceleration, alteration, and other costs and benefits of coal development and conversion plant operation, it cannot be determined whether housing, commercial services, and church investments will yield or receive net costs or benefits over the typical cost-benefit stream of the coal/energy development. Persons considering expansion of businesses or increased investment will not have the key information needed to assess the probabilities of individual success. Unfortunately, local decision-makers will not be able to acquire critical foreknowledge of impending social costs.

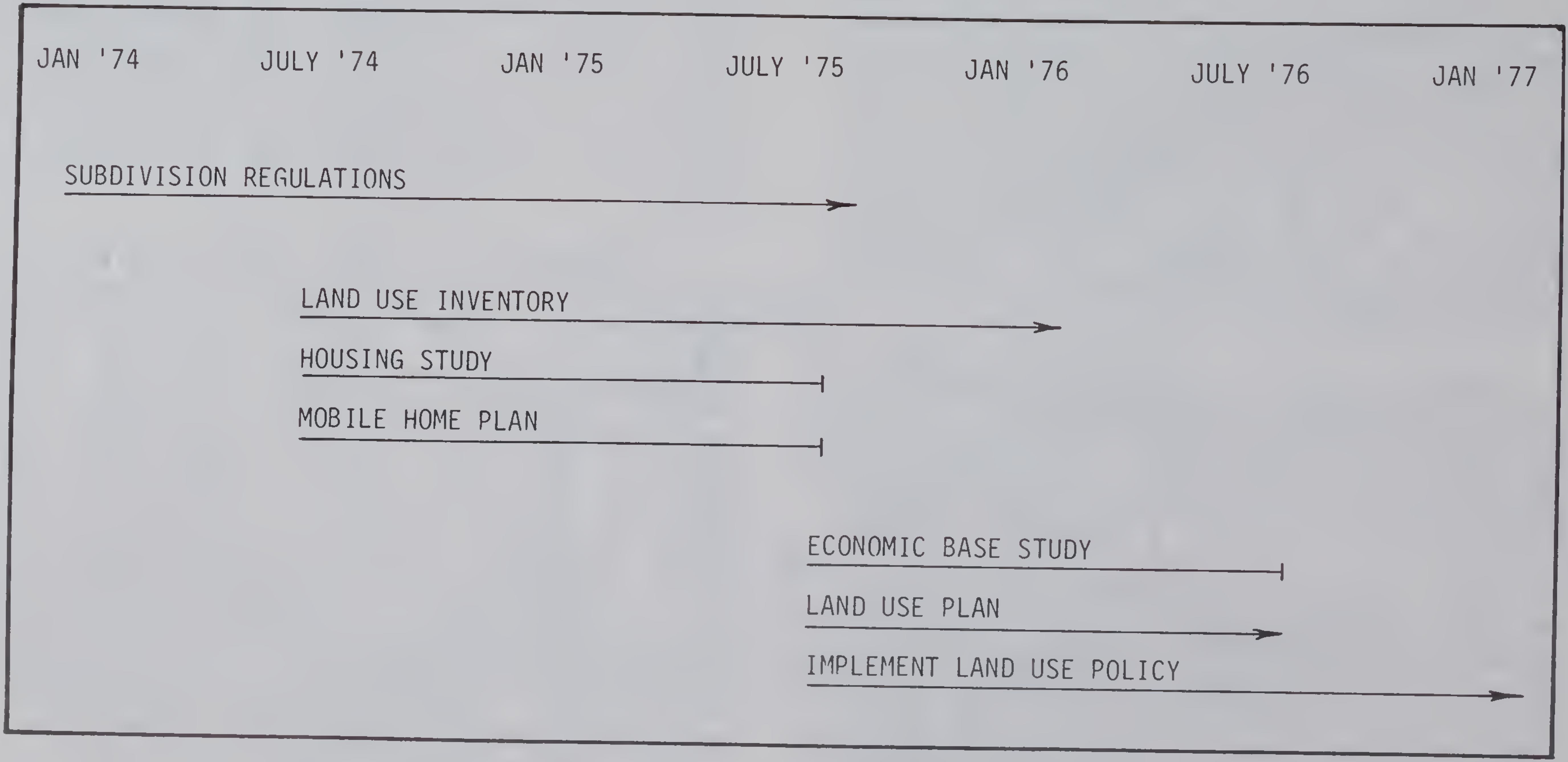
Some of the critical information gaps are basic socio-economic and land-use data. The Rosebud County Development Schedule (Figure 11-31) a time-flow chart for certain county planning efforts, indicates how county information programs will proceed.

This lack of information could become more critical if the county is unable to meet its anticipated time schedule. Even without this lag, however, much of the critical planning data for housing and commercial services could not be acquired until many of the impacts were already present. Additionally, the $19,500 overall budget proposed for these and a number of other service planning studies in the Rosebud County development schedule does not approach the cost of a thorough land-use inventory alone.

3. Churches

A fairly rapid influx of people could have both positive and negative effects on the churches of Colstrip and Forsyth. A continuing increase in participation and financial support may bring more full-time ministers and/or assistants to both towns, thus providing more church leadership. However, as ministers in Forsyth have recognized, the increased financial support may fluctuate rather drastically, as witnessed already by a period of high wages followed by a strike and a sizeable increase in the use of food stamps.

Furthermore, if some interviewed pastors were correct in their estimation that a smaller percentage of the new populace is involved in church affairs, the expected financial boost might not materialize. Additional pressure would also be placed upon churches to find ways to reach beyond their immediate congregations, if they are to offer relevant assistance in the resolution of the community's social problems. This may call for a combined, nondenominational effort among the churches, which would necessitate a closing (or overlooking) of the schism now existing between the fundamentalist and modernistic approaches. It is a distinct possibility that the different approaches to solving problems could further reduce the admitted low level of communications. It already appears that the churches are moving in opposite directions. The evangelical churches tend to seek the solution to social problems solely by getting the message of Christ to the people. Pastors feel that, by drawing the people close to Christ and to each other through Christ, social problems will diminish. On the other hand, a modernistic pastor felt that social problem study groups would be a good approach to help prevent and/or resolve social problems.



ROSEBUD COUNTY DEVELOPMENT SCHEDULE
(RICE 1974)

Figure 11-31

One evangelical pastor thinks the pastor preceding him was too "radical" and modern; consequently, part of his approach is to move back to the old ways of the church. One modernistic pastor thought that perhaps more modern worship services in his church would attract more people to join. One evangelical pastor thinks it is more important to involve people in activities presently sponsored by his church such as revival meetings and Bible study than to provide new services in the social realm. Another pastor sees a need for counseling on growing problems such as money management, family relations, and so on. This split in approach appears to stymie effective inter-church efforts. More significant than this split in doctrine and approach, however, is the fact that there is little sign that any of the churches are gearing up to handle an increase of the social problems churches typically are asked to handle, should such an increase occur.

11.2.2.4. Impacts on the Rosebud County Economy

In the next few sections, employment and earnings as well as public expenditures and revenues for Rosebud County over the next seven years will be examined. At the heart of these projections is the relationship between employment and population.

Recent history in Rosebud County shows an average ratio of population to employment of 2.33:1. This ratio is applied to each new primary job created to yield population figures. Secondary employment is then derived from the resulting population estimates. The results of such an approach reflect the implicit assumptions that all jobs are filled by people from outside the county and that each worker moving into the county brings 1.33 dependents with him or her. Since some jobs would probably be filled by present county residents, the results must be considered maximum population projections and maximum secondary job creation.

This does not raise a problem for comparisons made within these sections, since for the alternatives considered, projections are consistent with each other. However, these projections are not consistent with those made in Section 11.2.2.1.

The construction and operation of coal-fired generating units in Colstrip, Montana affects, in varying degrees, the people and the economies of Rosebud County, the rest of Montana, and the entire nation. However, the greatest impact will be felt within Rosebud County itself, with the towns of Forsyth and Colstrip and their school districts being the areas most affected. Thus, this economic analysis concentrates on the Rosebud County economy, the governmental units of the county and the city of Forsyth, and the school districts of Forsyth and Colstrip.

A. Projections of Employment and Earnings in Rosebud County

1. Methodology Limitations

The credibility of any economic analysis rests on an appraisal of the relative merit of the data and the technique used to derive the economic projections.

Looking first at the data, Montana has available the considerable expertise of the Regional Economics Division, Bureau of Economic Analysis, U.S. Department of Commerce. The economists in this division have assembled a yearly data series for all counties in the nation. The Montana county data from this source are by far the best, most consistent statistical series available at the county level.

However, this data series does have limitations. For example, the data in the files contain distortions within Standard Industrial Classification (S.I.C.) Codes at the county level which must be adjusted before the data is usable for detailed economic projections.

Secondly, the economic analysis must quantify relationships which must anticipate what people will do with their monetary resources. A noted English economist described this problem very succinctly when he said, "But, of course, economics cannot be compared with the exact physical sciences; for it deals with every-changing and subtle force of human nature". (Marshall 1920, p. 14).

At the most detailed geographic level the technique must put cases that represent highly qualitative relationships into numerical form. For example, people (employees or employers) must decide how much of their net earnings they will save and how much they will consume. They must decide whether or not they will save or consume locally or outside the county. The business entrepreneur must decide how much to invest and whether to invest locally or outside of the county. Ultimately it is these relationships which will determine the size and composition of a local county economy.

The process begins when the utility companies raise the investment capital for the Colstrip project. The beginning of construction marks the direct employment of people and purchasing of goods and services, some locally and some outside. Locally purchased goods and services create a demand for local labor. The businesses employ people to produce or simply sell the goods. The businesses pay wages and salaries to the employees, and the proprietors earn profits.

These monies, in addition to the earnings of those directly employed persons and the earnings of the remainder of people employed in the county, comprise the pool of money from which people either consume or save. Of major importance to the local economy is how much of the earnings are consumed or saved locally and how much is consumed or saved outside of the county. In most cases the capture of local consumption and savings dollars is determined initially by the quality of business services offered locally. If the local business community has an acceptable array of goods and services, people will consume locally; if not, they will go elsewhere.

After the initial stages of a major investment, the local investment decisions made either by local businessmen or by outside businessmen investing locally will affect the capture of the earnings dollars. Basically it is the amount of and assimilation of investment in any economy which determines the rate of economic growth.

The interrelationship between consumption, saving, and investment is what might be called a dynamic economic process. Some of the variables which affect the relationships are consumer-tastes, prices of goods and services, labor preferences, quality of goods and services, stock of capital, efficiency of the entrepreneur, etc. These concepts are relatively easy to understand; however, their quantification at a county or state level is quite another matter.

Of the items noted above, only the employment and earnings are available at the county or state level from a good quality, consistent source. Thus, the projection of employment and earnings must be accomplished by a statistical technique which is less dynamic than the process described.

2. Impact Techniques

In preparing the projections for Rosebud

County, emphasis was placed on analysis of the individual firm within major industries. The projection of employment used in mining, manufacturing, and transportation, communication, and public utility industries anticipated changes in physical output, changes in productive capacity, and changes in output per man. By utilizing any of these three, a degree of dynamics was introduced into the projection process. For example, the amounts of coal shipped from Westmoreland Coal, Western Energy, and Peabody Coal help determine the number of people employed by Burlington Northern in Forsyth, Montana.

a. Coal Mining

In the Rosebud County coal mining industry, individual company estimates of output per man were used in obtaining employment from projected coal tonnages to 1981. Once yearly employment projections were derived at the firm level, 1973 earnings based on total labor costs at the firm level were applied to arrive at total earnings per firm, and the firms within the industry summed to an industry level. In those few situations where proprietary earnings were present, 1973 proprietary earnings or a five-year average was used in the total earnings projections.

b. Agriculture

In agriculture, the Rosebud County earnings projections were based on physical quantities of production of particular agriculture commodities times the average 1973 prices of those commodities. In the livestock section, physical projections were based on Rosebud County's relative efficiency compared to state production for each commodity. In the crops section, acreage and yields per acre by commodity were used in the projection of physical quantities per commodity. The assumption was made that increasing acreage in Rosebud County would continue to be devoted to livestock input items (corn silage, hays and feed grains).

c. Construction

In the construction industry, projections were based on actual or anticipated capital expansion plans of individual firms or government entities. Construction employment projections for the Colstrip generation units and Western Energy's coal mining activities were based on engineering analysis, and they were time-sequenced based on construction timetables. Construction employment projections for Colstrip town projects, Rosebud County road projects, and other public projects and a residual construction element for the remainder of the county were incorporated into the projections.

d. Residence Adjustment

The Colstrip data were adjusted for out-of-county commuting using two commuting employment estimates obtained from Western Energy Company. Only two stock estimates (employment by place of residence at a point in time) were used. The out of Rosebud County employment commuting estimate was 10.4% in the winter and 25.1% in the summer of the total employment on the Colstrip project. Employment included Bechtel and the subcontractors. These estimates were averaged, and they were used to residence adjust all Rosebud County construction employment.

e. The Threshold Model

In the service industries, employment was estimated for each year based on population changes that occurred as a result of employment changes in the sectors of mining, manufacturing, agriculture, construction, transportation, communication, and public utilities. The technique used to estimate these changes is called a threshold model. The model projects the amount of service sector employment that will occur as a result of changes in the county population level induced by changes in employment in the primary sectors.

For each service industry there is a different threshold which determines the employment changes that will occur in that sector. For example, 200 new people in a community may generate enough sales of food to cause one new person to be employed in food retailing. However, it may take 20,000 people before enough brokerage sales are generated for a new employee to be added to a stock brokerage business.

In the development of the model it was found that a strong correlation existed between the number of people in Montana counties and the number of people employed in county service industries (35 S.I.C. code service sectors). There is numerical evidence to substantiate the fact that there is a relatively uniform demand for services (quantified by the employment of service personnel) in Montana counties, and this services demand is related to the population of an area. There are minimum population thresholds in some service sectors in which insufficient demand exists until population reaches a certain level.

The threshold model used here incorporates 35 separate regression equations into the calculation of four division level service sectors: (1) Wholesale-Retail Trade, (2) Finance, Insurance and Real Estate, (3) Services, and (4) Government. The relationship between population and employment estimated by the regression equations is based on county data for the entire state of Montana.

If population is the main determinant of the demand for services, the model will anticipate new levels of service sector demands and employment in that industry in a manner which approximates what actually happens in a dynamic economy.

It has been pointed out that local sales are a function of the level of total county consumption, the portion of total consumption dollars dispersed locally, the total amount of investment, and the portion of investment made locally. The end result of this dynamic process is the production of new levels of local employment and earnings. However, these consumption and investment relationships are unknown at a county level and unavailable at even the state level from a consistent, uniform statistical source.

The threshold model incorporates the fact that there is a relatively uniform demand for services in Montana counties as related to the number of people residing in a county. However, two sources of bias are introduced by using existing county data to estimate relationships between population and service sector employment. They are both imbedded in the fact that Rosebud

County, with the present and the proposed construction activity, may be an atypical county with respect to the relationships being measured.

The first bias is that the jobs in Rosebud County which will be causing the initial population changes are construction and mining jobs, and wages for both are higher than average Montana wages. The second bias, and probably much more important, is that the data used to estimate the population-service employment relationships come from a group of more or less stable counties whose rate of population change has been slow—essentially equilibrium conditions. Rosebud - County certainly will not conform to those conditions over the next six years. As a result, the service industries may be reluctant to make additional investments and hire additional people. If so, the following estimates of population and employment will be high. Therefore, the resulting projections should be interpreted as being upper bound estimates.

3. Projections

In a rapidly changing county economy, the most dynamic element of population change is employment. The activities of one firm can greatly affect the number of people employed in a community and, thus, its population. However, in using employment as the basis for the population projection, adjustments must be made for the number of people working in, but not living in, that community. Estimating population at a sub-county level is even more difficult, for the same reason, and is compounded by the lack of a consistent sub-county employment series.

In Colstrip, population is greatly affected by commuting patterns. These commuting patterns are a function of many variables including consumer preferences and availability of housing. Colstrip projections would be considerably less reliable than those at the county level.

Once county employment has been adjusted for the place of residence, another relatively stable relationship (that of population to total employment) is used to estimate population. Interestingly, the population to employment ratio exhibits considerable stability statewide, with a minor but stable difference for Rosebud County. The 2.33:1 population to employment ratio used in this study is a five year (1967 to 1972) average ratio for Rosebud County.

In order to estimate the effects of the possible construction and operation of Units 3 and 4, comparative estimates of Rosebud County had to be made assuming that those units are not built. The latter estimates, in turn, depended upon how coal mining is handled. Although specific areas may be earmarked for mining to fuel Units 3 and 4, one cannot assume that that coal can only be burned in Units 3 and 4. Such an assumption would imply that the only possible use of that coal is as fuel for Units 3 and 4. Certainly there are other markets.

Therefore, three alternative sets of assumptions were made. They are denoted as Scenario I, II, and III and are as follows:

Scenario	Generating Units Constructed	Coal Production (all cases include existing contracts)
I (Minimum Growth)	1,2	Coal for 1,2
II (Coal Export)	1,2	Coal for 1,2,3,4
III (Maximum Growth)	1,2,3,4	Coal for 1,2,3,4

The difference between Scenario II and Scenario III is one of where the coal is utilized. In II, it is mined and shipped out of Rosebud County; in III, Units 3 and 4 are constructed at Colstrip, and the coal is burned there. All scenarios include present sales contracts as a part of coal production.

Employment projections for the years 1973 through 1981 for each scenario are presented in Table 11-112. In each scenario, the first six employment categories were established by interviews or independent estimates. The TCPU classfication consists of transportation, communications and public utility employment. The last employment category (Service Sector Employment) was determined by the threshold model estimates and is a function of the previous year's population. This employment category includes the wholesale and retail trades, finance, insurance and real estate, government employees and non-farm proprietors.

a. Minimum Growth - Scenario I

From 1972 to 1974, without any economic activity related to Units 3 and 4, Rosebud County personal income will grow by 119% (see Table 11-113). In the same two years county population will expand by almost 60%, from 6,400 people in 1972 to 10,744 people in 1974.

b. Coal Export - Scenario II

If Units 3 and 4 are not constructed but coal related to them is mined, personal income will be $50,322,000 in 1981, some 15% higher than total real personal income at the end of construction of Units 1 and 2. The county population under the same scenario would be 11,084 people by 1981, 8.7% higher than at the end of construction of Units 1 and 2.

c. With Units 3 and 4 - Scenario III

If Units 3 and 4 are constructed, the mechanisms, legal, economic and practical, for assimilation of massive economic growth at the county level become all the more important. With Units 3 and 4, between 1974 and 1977 the county must assimilate another $26,654,000 in real personal income and an additional 5,408 people. This is in addition to the 1 9% increase in real personal income and the 60% increase in people from Units 1 and 2. By 1977, Rosebud County would have a population about 2½ times its 1972 population, and total personal income would be

TABLE 11-112

Residence Adjusted Employment Estimated For Alternative Scenarios, Rosebud County, 1973 to 1981

	1973	1974	1975	1976	1977
Scenario I:					
Ag. Proprietors	406	402	398	396	394
Mining Employees	217	199	289	469	540
TCPU Employees	159	227	273	300	302
Ag. & Ag. Serv. Employees	300	308	316	325	333
Manfg. Employees	131	150	161	167	171
Construction Employees	1759	2334	2560	2584	2558
Total County Employment	3333	4611	4604	4437	4347
Scenario II:					
Ag. Proprietors	406	402	398	396	394
Mining Employees	217	199	289	469	540
TCPU Employees	159	227	273	300	302
Ag. & Ag. Serv. Employees	300	308	316	325	333
Manfg. Employees	131	150	161	167	171
Construction Employees	361	991	607	196	49
Serv. Sector Employment	1759	2334	2560	2584	2558
Total County Employment	3333	4611	4604	4437	4347
Scenario III:					
Ag. Proprietors	406	402	398	396	394
Mining Employees	217	199	289	469	540
TCPU Employees	159	227	273	320	382
Ag. & Ag. Serv. Employees	300	308	316	325	333
Manfg. Employees	131	150	161	167	171
Construction Employees	361	991	912	1105	1225
Serv. Sector	1759	2334	2763	3332	3887
Total County Employment	3333	4611	5112	6114	6932

TABLE 11-112 (Cont.)

Residence Adjusted Employment Estimates For Alternative Scenarios, Rosebud County, 1973 to 1981

	1978	1979	1980	1981
Scenario I:				
Ag. Proprietors	393	392	391	390
Mining Employees	543	580	552	552
TCPU Employees	314	322	323	323
Ag. & Ag. Serv. Employment	335	337	339	341
Manfg. Employees	173	173	166	161
Construction Employees	67	65	41	41
Serv. Sector Employment	2563	2595	2580	2568
Total County Employment	4388	4464	4392	4376
Scenario II:				
Ag. Proprietors	393	392	391	390
Mining Employees	583	701	713	713
TCPU Employees	314	322	323	323
Ag. & Ag. Serv. Employment	335	337	339	341
Manfg. Employees	173	173	166	161
Construction Employees	67	65	41	41
Serv. Sector Employment	2590	2695	2752	2788
Total County Employment	4455	4685	4725	4757
Scenario III:				
Ag. Proprietors	393	392	391	390
Mining Employees	583	701	713	713
TCPU Employees	408	417	418	418
Ag. & Ag. Serv. Employment	335	337	339	341
Manfg. Employees	173	173	166	161
Construction Employees	667	208	41	41
Serv. Sector Employment	3930	3739	3509	3353
Total County Employment	6489	5967	5577	5417

approximately 3¼ times the 1972 level.

d. Comparison of the Three Scenarios

In Figure 11-32, population and employment projections are displayed through time. The implication of the projections is that population and employment will essentially level off unless Units 3 and 4 are built. If Units 3 and 4 are constructed, Rosebud County's population would grow to 16,152 in 1977, or 6,023 more than without Units 3 and 4. Whether or not this stress is worth the addition of 2,285 short term jobs (including secondary employment at peak difference in 1977) is open to question. On a long term basis the effects of Units 3 and 4 on both population and employment (see "Beyond 1981" in Table 11-113 and Figure 11 -32) are not very large. Whereas the coal mining associated with export of coal in Scenario II would add 477 permanent jobs, the manning of Units 3 and 4 would add only 282 more direct and secondary jobs.

Construction of Units 3 and 4 will add very great population stress in Rosebud County as compared to Scenarios I and II. Construction will also add a correspondingly large number of jobs, but the large employment impact will occur only during construction, and the permanent employment impact of Units 3 and 4 on the Rosebud economy will be much smaller than the impact of mining itself. To the extent that coal shipping would add job opportunities in Rosebud County, the effect of Units 3 and 4 (Scenario III) on long range employment above and beyond Scenario II would be still smaller.

e. Comparison of Rosebud County Projections With Other Regions

Per capita personal income is a basic economic measure of material well-being. When compared with that in other geographic areas, it becomes a measure of relative affluence. In Figure 11 -33, the per capita personal income (in current dollars) is charted for the United States, Montana, and Rosebud County from 1949 to 1972. In times past Montana's per capita income has exceeded the national average, but since 1950 Montana's per capita income has been below the national average. Rosebud County's relative income measure has exceeded the Montana measure on occasion, but has never exceeded the national average.

With energy development in Rosebud County, per capita personal income will exceed the Montana measure and on occasion exceed the U.S. average. In Figure 11 -34, per capita personal income has been charted for the three scenarios using a current dollar base. By 1980 real income per individual will exceed the Bureau of Economic Analysis' projected real per capita personal income for Montana, but it will be slightly below the national average (98%).

TABLE 11-113

Earnings, Personal Income, Employment, and Population 1972 to 1981, and Employment and Population Differences Beyond 1981, Rosebud County, Alternative Scenarios

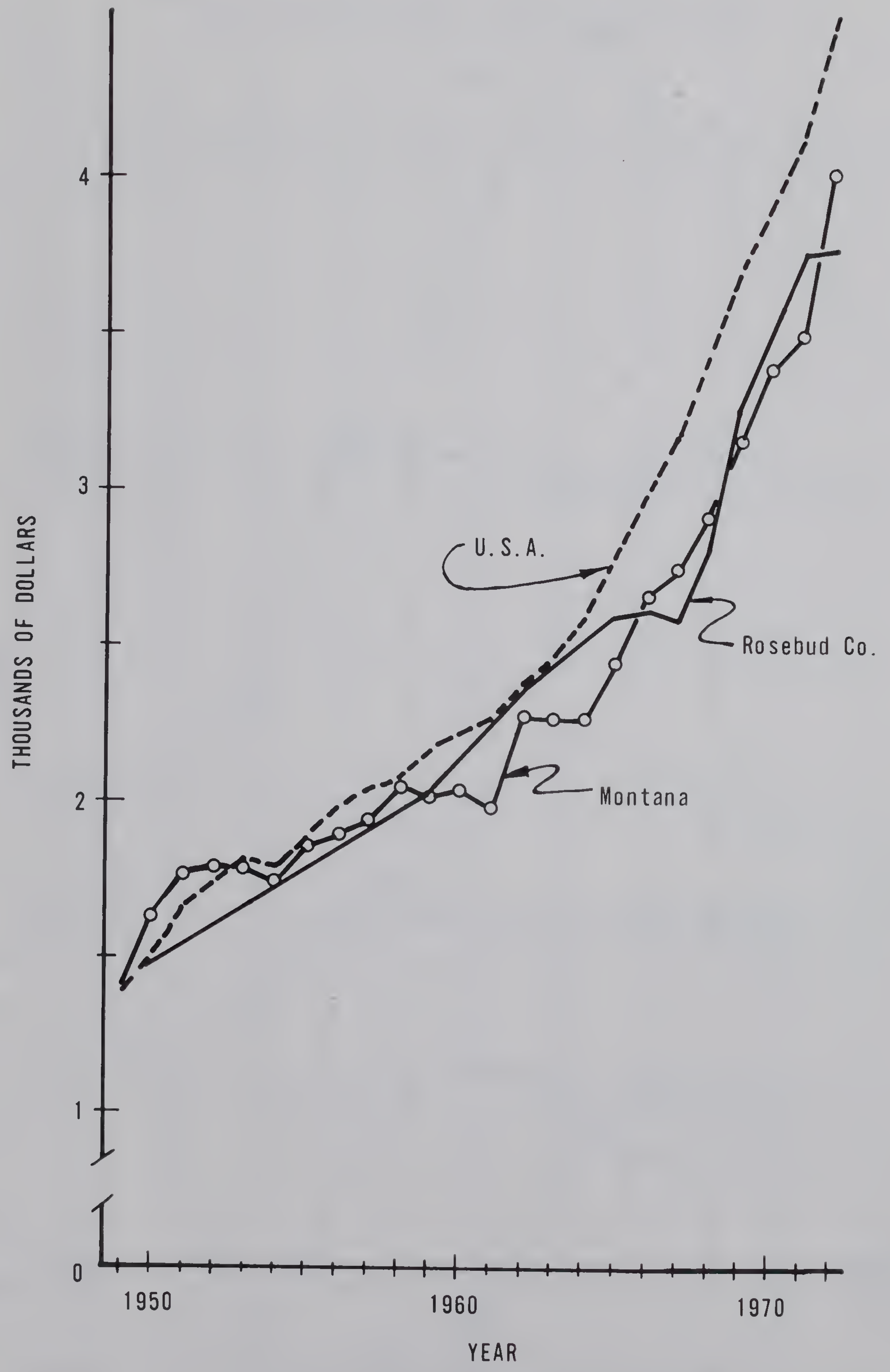
	1972	1973	1974	1975	1976
Scenario I:					
Earnings (000$)	19,412	28,298	43,133	40,835	37,164
Personal Income (000$)	24,191	34,762	52,984	50,161	45,633
Employment	2,909	3,333	4,611	4,604	4,437
Population	6,400	7,766	10,744	10,727	10,338
Scenario II:					
Earnings (000$)	19,412	28,298	43,133	40,835	37,164
Personal Income (000$)	24,191	34,762	52,984	50,161	45,633
Employment	2,909	3,333	4,611	4,604	4,437
Population	6,400	7,766	10,744	10,727	10,338
Scenario III:					
Earnings (000$)	19,412	28,298	43,133	47,374	57,633
Personal Income (000$)	24,191	34,762	52,984	58,194	70,797
Employment	2,909	3,333	4,611	5,112	6,114
Population	6,400	7,766	10,744	11,911	14,246

TABLE 11-113 (Cont.)

Earnings, Personal Income, Employment, and Population 1972 to 1981, and Employment and Population Differences Beyond 1981, Rosebud County, Alternative Scenarios

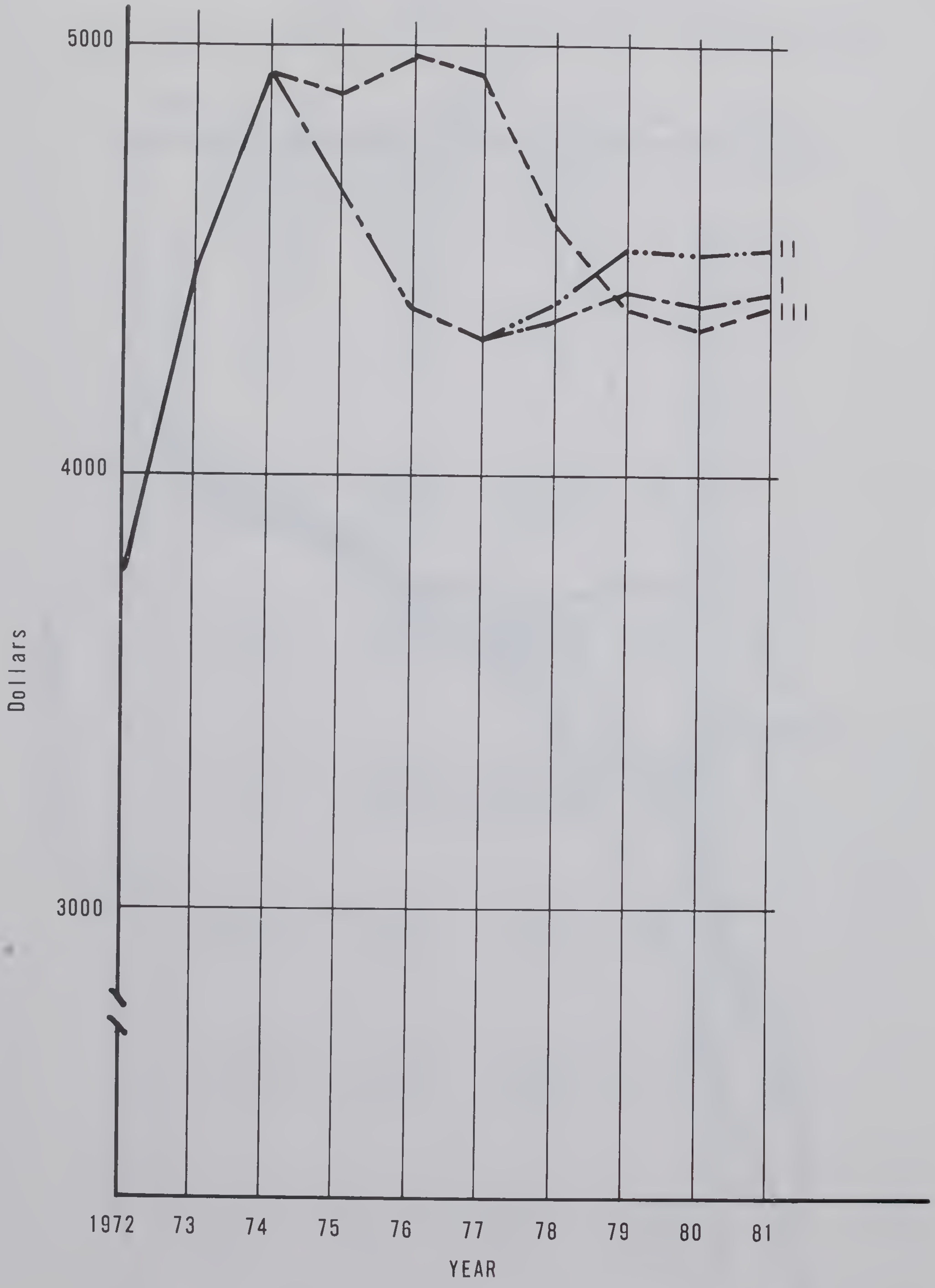
	1977	1978	1979	1980	1981	Beyond* 1981
Scenario I:						
Earnings (000$)	35,517	36,344	37,485	36,663	56,778	
Personal Income (000$)	43,629	44,645	46,046	45,037	45,178	
Employment	4,347	4,388	4,464	4,392	4,376	Base
Population	10,129	10,224	10,401	10,233	10,196	Base
Scenario II:						
Earnings (000$)	35,517	37,225	40,262	40,576	40,966	
Personal Income (000$)	43,629	45,728	49,458	49,844	50,322	
Employment	4,347	4,455	4,685	4,725	4,757	+ 477
Population	10,129	10,380	10,901	11,009	11,084	+1,112
Scenario III:						
Earnings (000$)	64,830	56,458	49,771	45,935	45,251	
Personal Income (000$)	79,638	69,353	61,138	56,426	55,586	
Employment	6,932	6,489	5,967	5,577	5,417	+ 759
Population	16,152	15,119	13,903	12,994	12,622	+1,768

*Differences represent population and employment differences between three scenarios



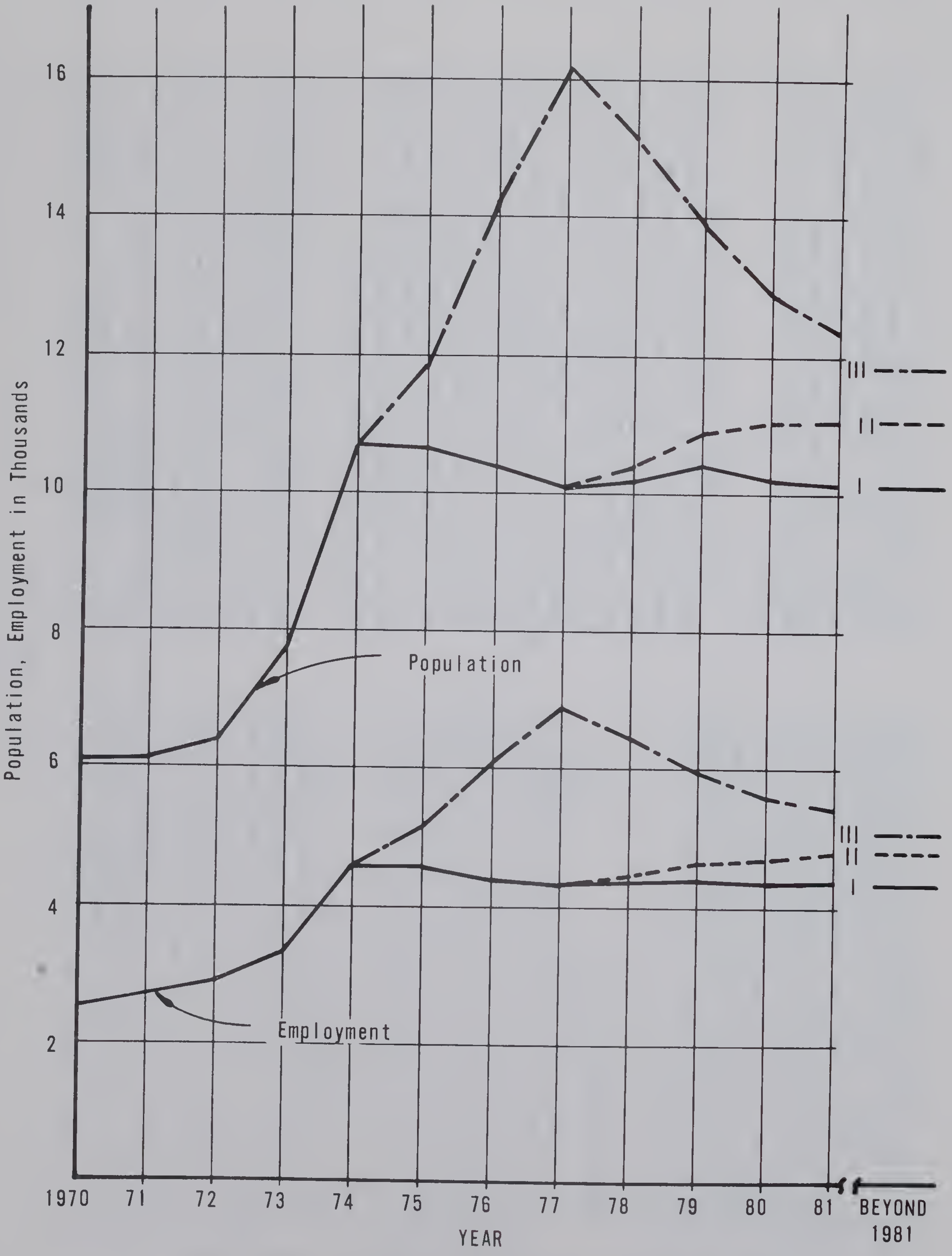
Per Capita Personal Income; Rosebud County, Montana, and the U.S.A., 1949-1972, in Current Dollars

FIGURE 11-33



Per Capita Personal Income, Rosebud County
1973–1981 in Current Dollars. Scenarios I, II and III

FIGURE 11–34



EMPLOYMENT AND POPULATION 1970–1981 AND BEYOND 1981
ROSEBUD COUNTY, SCENARIOS I, II AND III

FIGURE 11–32

In all three scenarios, as construction winds down and operational people begin working in the county, and as the county expands its service sectors, personal income per person will decline from the peak construction period incomes. Interestingly, per capita personal income in scenario II, a maximum coal mining scenario, exceeds the real per capita personal income in scenario III with Units 1,2,3, and 4. This is due to the relatively high wages paid in the coal mining industries.

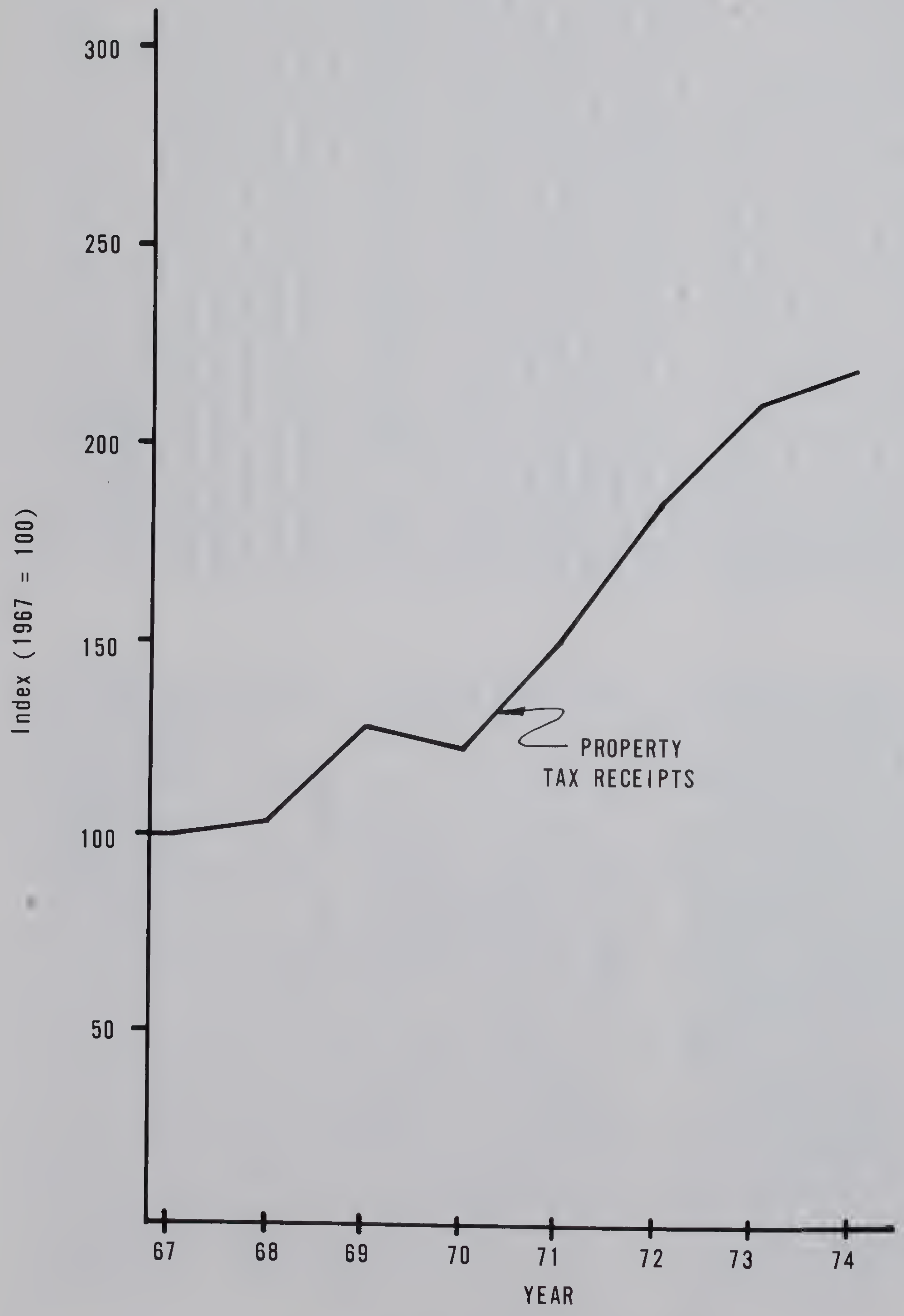
B. Local Government Finances

To estimate the public sector impacts of a project like the plants at Colstrip, where very large investments are concentrated at one relatively small site, it is necessary to take into account some levels of local government other than the county. For purposes of this analysis these are the incorporated towns (in this case the only one, Forsyth)-and the school districts.

In the bookkeeping for county government in Montana, several principal sources of receipts are identified. These include general revenue (taxes) and a number of miscellaneous revenues from collections, fees and licenses, rentals and sales, payments from state and federal sources for specified purposes and, in recent years, revenue sharing. It is with funds from these sources that the county governmental operations are run. As with other counties in Montana, however, the largest share of funds handled by the county are the so-called trust and agency, or "T & A" Receipts. These pass through the county treasury from state, federal, and local sources to the school districts and other special districts, with the county government acting as banker for the funds but not sharing in their use directly.

The primary source of county income (aside from the T & A accounts) is the ad valorem property tax, levied on varying proportions of the assessed value of real and personal property and on various other values, some of which come into the discussion later. In Rosebud County since 1967, the proportion of county income provided by property tax has varied from 75% or more to around 40%. Although the proportion has decreased with the increase in other components such as revenue sharing, the amount of the tax has increased,as shown in Figure 11-35. The trend can be explained by a combination of increasing costs, rising taxable valuations, and the general expansion of government services.

Since 1967, that part of the total millage rate in Rosebud County for general government purposes has remained nearly constant, but, because of the requirements for education costs, the total rate has increased from 75.4 mills /84 in fiscal year 1966-1967 to 1 4.2 mills in 1973-1974, according to reports of the Montana Taxpayers' Association. Total taxable valuation of real and personal property in the county decreased in the 1960's before 1967, but between



Indexes of Rosebud County
Property Tax Receipts, 1967-1974

FIGURE 11-35

that year and 1973, partly under the influence of increased coal development, it rose at an average rate of 6½% per year.

The actual rate is determined each year by a process of budget estimation for each fund (or general category of use) for the next fiscal year. From the total estimated requirements there is subtracted the expected sources of revenue other than ad valorem taxes. The remaining amount is then divided by the applicable taxable property valuation to determine the millage rate.

The process, however, is subject to a number of restrictions and controls. No significant increase in revenue levels can take place without a public hearing. The county commissioners are not in general permitted to accumulate funds in anticipation of unusual future requirements and the statutes set millage limits for each fund, based on the classification of the county, which is determined by the county's total taxable valuation. Rosebud County has just moved from a Class 5 status to a Class 4 county due to increased taxable valuation in the county.

1. Coal Taxes

Before proceeding to a discussion of the impact of the Colstrip plants on tax levels in the county, a review of the relevant taxes applying to coal operations in the county is in order. For an operation like the Colstrip complex, there are five coal-based taxes in Montana that apply, and another on the production and sale of electrical power. Three of these taxes, the Corporate License Tax, the Resource Indemnity Trust Fund Tax, and the Electric Energy Production License Tax, are paid to the state and do not affect county finances. The remaining three contribute directly to the county, two of which contribute through the county to the school district in which the coal is mined. As it happens, both coal mines in the county are in school district #19, the Colstrip district.

Besides real and personal property taxes, paid at rates which combine the millage of the county and the district and are applied to 40% of the assessed valuation, the operators of a strip coal mine are also taxed on the net proceeds of the mine. The same combined millage rate is applied to the gross value of coal mined during the year, less the costs of production (including land reclamation costs), but taxed at the full assessed value. In addition, the 1974 legislature provided that 3 cents per ton of coal mined, regardless of its value, is returned by the Montana Department of Revenue each year to the general fund of the county in which the coal is mined. In Rosebud County this 3 cents comes out of a total of 34 cents per ton which the state collects on coal with the heat value (BTU per pound) of the subbituminous coal mined there.

2. Projections

We proceed now to estimate the effect of the proposed Colstrip plants on the tax burden of county residents. The effects were not district by district, because public services are a function of population, and population statistics are not reported by school or other special district. Consequently, it was decided to make use of a combination of three sources, the Montana Department of Revenue, the annual reports of the County Clerk and Recorder, and the Forsyth city records. Using a combination of school levies and special levies, reported biennially by the Montana Department of Revenue and measures of the local-tax supported portion of county and city government expenditures gives a measure for which there are historical records for comparison, and which can be projected into the future along with other measures presented in this study. The most important of these is probably population, projections for which have been made based on the three scenarios. Next, assumptions have to be made as to future costs of governmental services supplied by the county and its units.

a. Local Tax Supported County Government Expenditures

Per capita costs of county government have shown a not-surprising increase in recent years, although some of the apparent increase can probably be attributed to the difficulties in making accurate population estimates. The Census Bureau, for example, reported Rosebud County's population to be constant from 1967 to 1971. During this period actual counts of student population were increasing fairly steadily, and expenditures for county government rose from one-half million to nearly one million dollars.

If it is assumed, however, that the range, magnitude, and per capita costs of services provided by county government through 1981 will be about the same as they were on the average for the years 1973 and 1974, then this basis can be used to project county budget through 1981. Using this method, county budgets for the years 1974-1975 through 1980-1981, based on scenario III population projections, would be as follows to the nearest $500:

Year	County Budget
1975	$2,779,500
1976	3,324,500
1977	3,769,000
1978	3,528,000
1979	3,244,500
1980	3,032,000
1981	2,945,500

These figures represent total county budget figures. Since 1967, 60.6% of the total county budget was raised by property taxation. It is assumed that this percentage will be representative in the future. The above figures are thus multiplied by .606 to derive column 2 in Table 11-114 ("Local Tax-Supported County government Expenditures") for Scenario III. Since these figures have been estimated on a per capita basis, the corresponding numbers for Scenario's I and II are

TABLE 11-114

Estimated Rosebud County Tax-Supported Governmental Costs (1973 Dollars) Projected To 1981 With Taxable Valuation, Composite Millage Rates.

Scenario I Projections

Year	Local Tax-Supported County Gov't. Expenditures ($000's)	School District Costs ($000's)	Forsyth City Tax Costs (000's)	Bond Retirement Cost	Coal Mines License Tax Receipts ($000's)	Total Expenditures ($000's)	Taxable Valuation ($000's)	Required Millage Rates
1974	1520	2176	115.0		153	3658.00	25692	142.4
1975	1518	2173	114.8	53350	255	3604.15	36775	98.0
1976	1463	2094	110.6	"	459	3261.95	46803	69.7
1977	1433	2052	108.4	"	543	3103.75	56835	54.6
1978	1446	2071	109.4	"	543	3136.75	60475	51.9
1979	1472	2107	111.3	"	573	3170.65	60020	52.8
1980	1448	2073	109.5	"	543	3140.85	59998	52.3
1981	1443	2065	109.1	"	543	3127.45	59842	52.3

TABLE 11-114 (Cont.)

Estimated Rosebud County Tax-Supported Governmental Costs (1973 Dollars) Projected To 1981 With Taxable Valuation, Composite Millage Rates.

Scenario II Projections

Year	Local Tax-Supported County Gov't. Expenditures ($000's)	School District Costs ($000's)	Forsyth City Tax Costs ($000's)	Bond Retirement Cost	Coal Mines License Tax Receipts ($000's)	Total Expenditures ($000's)	Taxable Valuation ($000's)	Required Millage Rates
1974	1520	2176	115.0		153	3658.00	25692	142.4
1975	1518	2173	114.8	53350	255	3604.15	36775	98.0
1976	1463	2094	110.6	"	459	3261.95	46803	69.7
1977	1433	2052	108.4	"	543	3103.75	56835	54.6
1978	1469	2102	111.1	"	585	3150.45	60475	52.1
1979	1544	2211	116.8	"	699	3226.15	61576	52.4
1980	1558	2230	117.8	"	711	3248.15	64665	50.2
1981	1568	2245	118.6	"	711	3273.95	66064	49.6

TABLE 11-114 (Cont.)

Estimated Rosebud County Tax-Supported Governmental Costs (1973 Dollars) Projected To 1981 With Taxable Valuation, Composite Millage Rates.

Scenario III Projections

Year	Local Tax-Supported County Gov't. Expenditures ($000's)	School District Costs ($000's)	Forsyth City Tax Costs ($000's)	Bond Retirement Cost	Coal Mines License Tax Receipts ($000's)	Total Expenditures ($000's)	Taxable Valuation ($000's)	Required Millage Rates
1974	1520	2176	115.0		153	3658	25692	142.36
1975	1685	2413	127.4	53350	225	4024	36775	109.42
1976	2016	2885	152.4	"	459	4640	51003	91.12
1977	2285	3271	172.8	"	543	5240	70035	74.81
1978	2139	3062	161.8	"	585	4831	85875	56.26
1979	1967	2816	148.8	"	699	4287	96829	44.27
1980	1838	2632	139.0	"	711	3952	101911	38.78
1981	1786	2556	135.1	"	711	3819	103910	36.76

different only because of differences in projected population base (see Table 11-113 for underlying population projections). For all three scenarios the figure of $141.80 per capita is used.

b. School District Costs

Expenditures for education exceed all other county expenses put together, so these must be added to the totals so far. The basis for projection of this public expenditure in the present analysis is tax cost per student, which in Rosebud County averaged $913.25 in the school years 1972 and 1973 -- with considerable variation between schools and school districts. This figure is used in the projections under column 3 of Table 1 -114.

Student population estimates have been based on the historical relationship between total population and numbers of enrolled public school students in the county. This basis is likely to give a somewhat overstated student population, because the greatest population "peaks" in the future projections are caused by the presence of construction workers, who include a somewhat higher proportion of single persons than in the customary population of Rosebud County before and after the construction period.

c. Forsyth City Tax Costs

Taxes supporting local government of the city of Forsyth were included. Most of the funds for this purpose come from fees and charges arising out of the city's operations, but amounts varying from 25% to 36% of the total in recent years have come from taxation. For estimates of future amounts it was assumed, to be safe, that the population of Forsyth would tend to change at a rate corresponding to that of the county. Tax-supported expenditures for Forsyth have averaged $10.70 per capita using county-wide population as the base, so this figure was used to compute the column in Table 11-114 on "Forsyth City Tax Costs".

d. Bond Retirement Costs

It was assumed that, beginning in 1975, a total of $1,000,000 would have to be raised by a bond issued for capital expenditures -- in this case, 20-year serial bonds at a 6.7% interest rate. This would cover such items as a new school building for Colstrip, a jail at the county seat, purchase or construction of other school facilities there, or other expenditures.

In actual practice, of course, this is not the way capital-expenditure funds would be raised, since the county does not sell bonds for construction of schools in a particular district. To be completely realistic, careful and detailed estimates would have to be made, taking into account the finances of the district in which school construction would take place and in which bonded indebtedness would be incurred.

School districts are limited, in the bonded indebtedness they may incur, to 5% of the total assessed valuation. In 1974, however, Colstrip Elementary School District, with an assessed valuation of $17 2/3 million, still has a permissible margin of $842,543 it may raise by bond issues; and for the high school district, the permissible amount is $847,085. Similarly, the Forsyth Elementary and high school districts have margins of $556,944 and $773,150, respectively.

e. Coal Mines License Tax

Beginning with 1974, additional funds began coming into the county's General Fund from the Strip Coal Mines License Tax. At 3¢ per ton of coal mined by Western Energy and Peabody Coal Companies, this tax will contribute amounts starting with $225 thousand in 1975 and rising to $711 thousand in 1980 and 1981. These amounts are subtracted from the dollars to be raised by property taxation each year in the projections.

f. Taxable Valuation

Since 1967, Rosebud County's tax base (measured by total taxable valuation) has approximately doubled, from about $10 million to just under $20 million, with most of the growth taking place since 1970. In the future there would be two sources of increase in the tax base as a result of coal company operations. One would be the increased valuation of the power generation and coal mining complexes and the residential and commercial growth of Colstrip. The other would be the net proceeds, based on value of the mine coal itself, less the cost of producing it. For purposes of this particular discussion, however, only the taxable net proceeds of Western Energy Company are included, so the taxable values are understated each year by the amount of Peabody's net proceeds. Figure 11-36 shows what would happen to taxable valuation in the county if we assume all other valuation remains constant at the 1974 level.

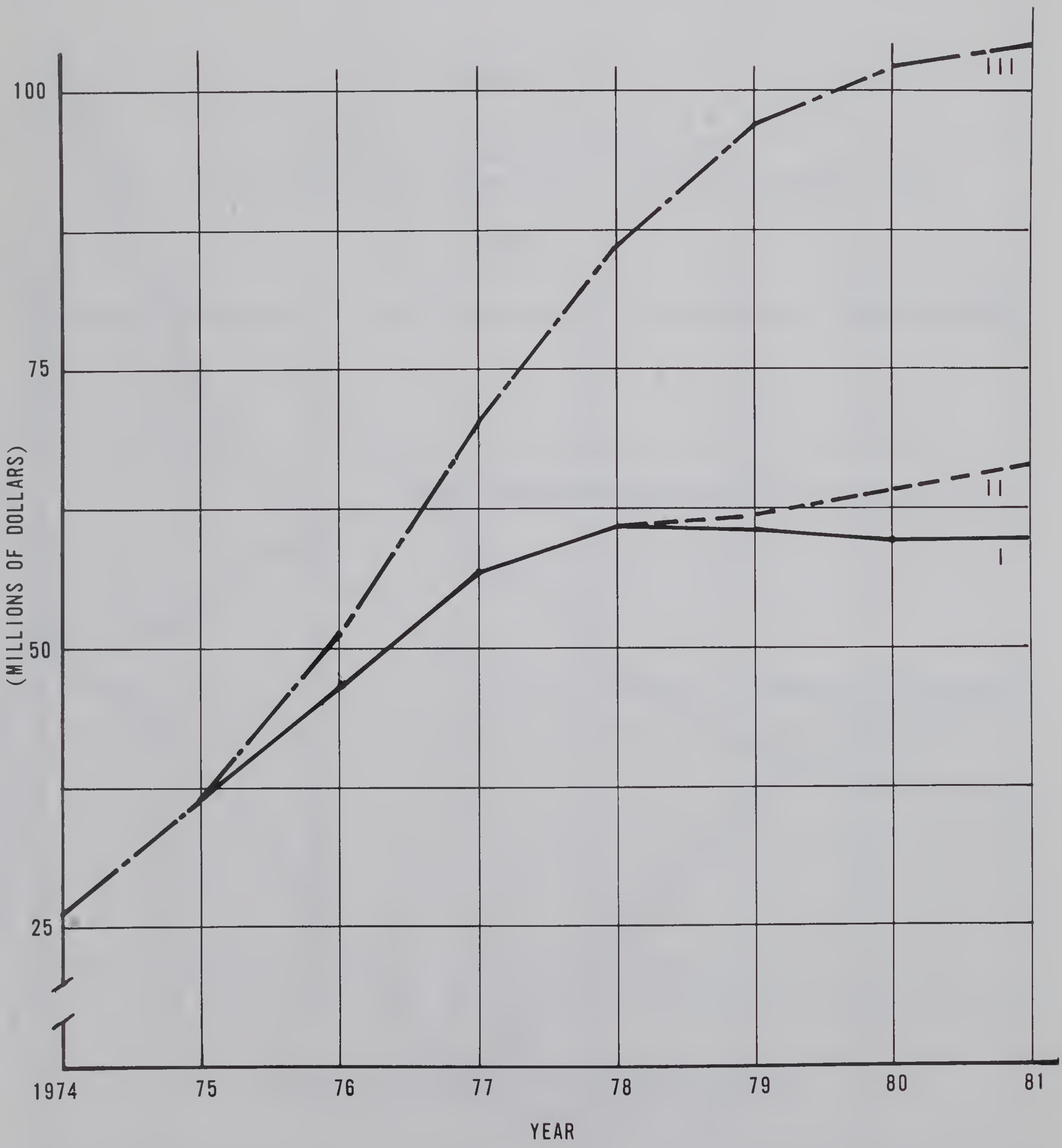
Based on these rather conservative assumptions, and using the total governmental expenditure projections described above, it is then possible to compute a sort of composite millage rate required each year to raise the necessary funds.

g. Required Millage Rates

Results of the calculations of projected total county government costs supported by local taxation, and composite millage rates based on future increases in taxable valuation, are given in Table 11-114. The required millage rate is calculated by dividing taxable valuation into the total expenditures.

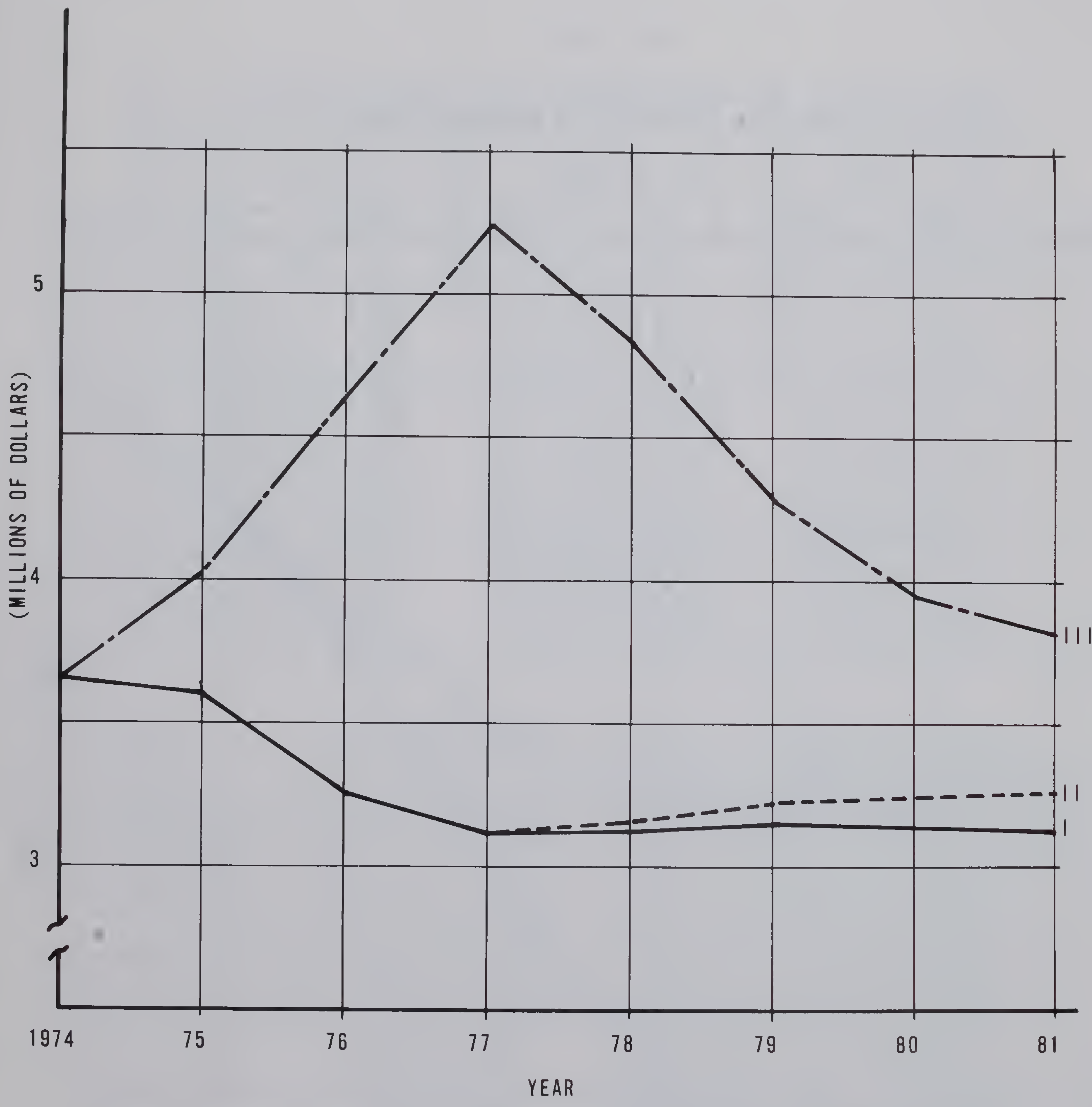
h. Summary of Projections

Estimated total expenditures and millage rates are shown graphically in Figures 11-37 and 11-38. Because expenditures are linked closely to population, they peak in 1977, the year of maximum population under Scenario III conditions.



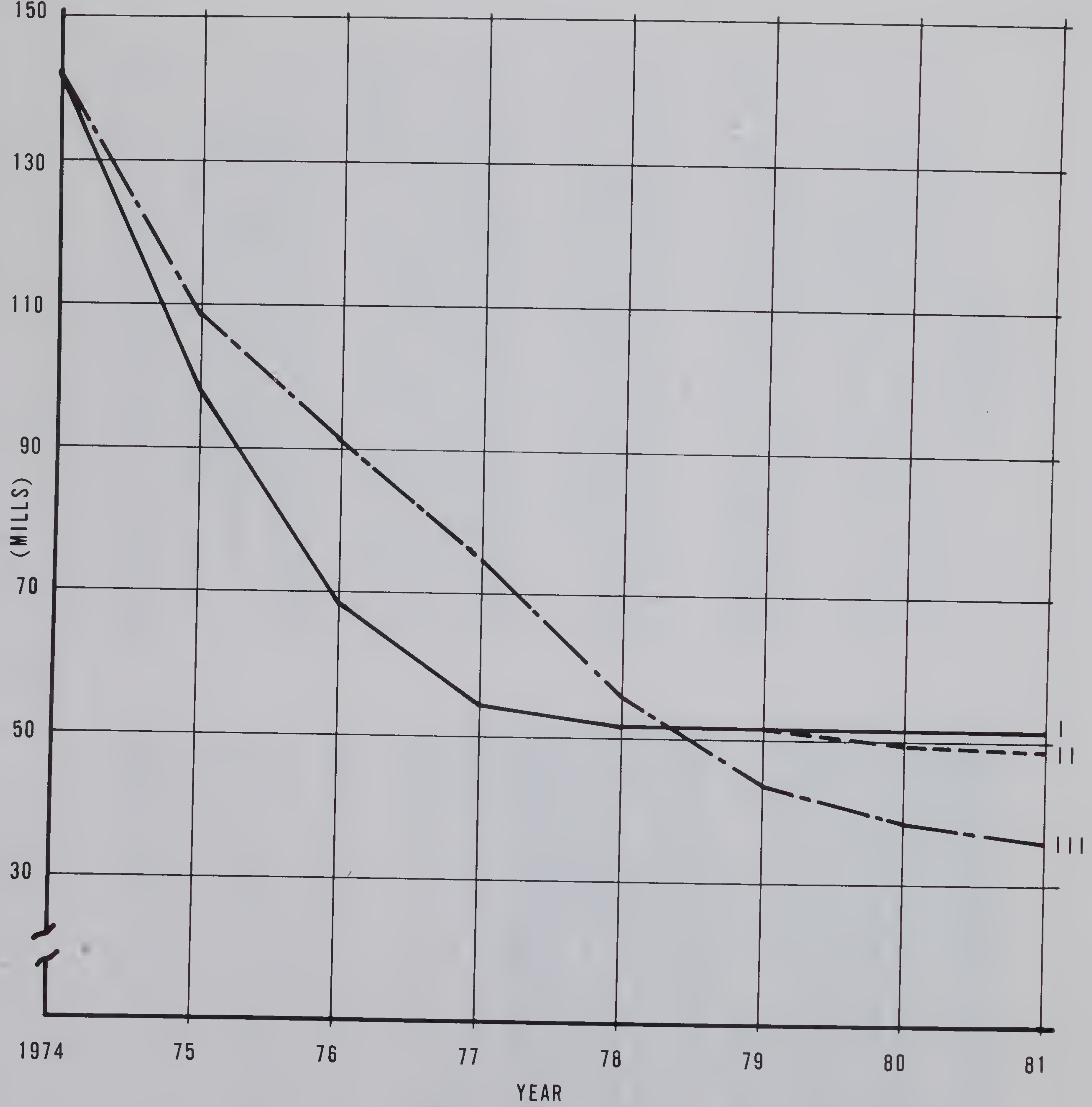
Estimated Rosebud County Taxable Valuation
Scenarios I, II and III, 1974-1981

FIGURE 11-36



ESTIMATED ROSEBUD COUNTY TOTAL EXPENDITURES TO BE COVERED BY PROPERTY TAXES.
SCENARIOS I, II AND III, 1974 to 1981

FIGURE 11–37



ESTIMATED ROSEBUD COUNTY REQUIRED MILLAGE RATES
SCENARIOS I, II AND III, 1974 to 1981

FIGURE 11-38

Under either Scenario I or Scenario II, expenditures peak in 1974. For all three scenarios, predicted millage rates fall from 1974 forward, but they should fall much more sharply over the next four years under Scenarios I and II than they would under Scenario III. Starting in 1979 Scenario III millage rates fall substantially below required millage rates for the other two scenarios, as Units 3 and 4 would come fully into the county property base.

Once again, it should be remembered that these projections do not represent millage rates for taxpayers in any one location, but are composite rates indicating a county-wide average. There is an obvious high point for millage rates in the current year, if expenditures follow the assumptions made in these projections. This is indicative of the problems facing the county now, during the current construction and the resulting population increases.

FOOTNOTES
CHAPTER ELEVEN

1. Normally 50-75' for mechanical draft versus 300 to 500' for natural-draft towers.

2. The farthest downwind distance at which applicable measurements were made.

3. The design parameters of the proposed towers were: outlet height 250', discharge diameter 180', and a fan-forced discharge velocity of 1110 ft./min.

4. The inconsistency involved the fact that plume trajectory was best predicted from the rise of a single-cell plume, while plume visibility was best handled by assuming entrainment into all seven of the operating tower cell plumes.

5. Several different definitions of particle size exist, including those based upon geometrical shape, optical properties, and settling velocity. Unless otherwise stated, size as used here means aerodynamic diameter; that is, the diameter of a unit density sphere having the equivalent settling velocity as the particle in question.

6. Some appropriate settling velocities in still air at 0°C and 1 atmosphere pressure for various aerodynamic particle size include:

.1u, 8×10^{-5} cm/sec; 1u, 4×10^{-3} cm/sec;
10u, 0.3cm/sec; 100u, 25cm/sec
(Air Quality Criteria for Particulates, 1969)

7. A more detailed anatomical and functional discussion of the respiratory system can be found in the Air Quality Criteria for Particulate Matter (1969) or Stern et al. (1973), or Williamson (1973).

8. During conditions of limited mixing the binormal distribution in the vertical is assumed only until a limiting downwind distance is reached. After this distance is exceeded, pollutants are assumed to be homogeniously mixed in the vertical.

9. This assumption is fundamental to the derivation of the Gaussian model (Turner 1970 and Stern et al 1973). However, to a certain extent the Gaussian model could be "patched up" to account for reactivity by allowing a given pollutant concentration to decay with time and hence downwind distance. Unfortunately, the chemistry of a fossil-fuel power plant plume is complex, and the decay rates of the various constituents including sulfur dioxide are not well known.

10. These figures were derived by making T_i=to one hour and T_f=to three hours and 24 hours, respectively. The equation $\frac{T_i}{T_f}$ 0.2 was subsequently used to arrive at values .80 and .53.

11. The specific identification number of the program is CIR3D.

12. Since the conditions predicted by the traditional Pasquill E and F curves did not appear to occur at Colstrip, terrain considerations were not included in the modeling.

13. All concentrations reported in parts per million assume pressure of one atmosphere and temperature of 298°K.

14. The effective stack height predicted using Briggs' (1969) unstable and neutral plume rise equation for wind speeds of 5.4 m/sec. and 2m/sec. were: Units 1 and 2, 520m and 1140m; and Units 3 and 4, 540m and 1190m.

15. Published in March 1974 by Heimbach and Super.

16. The size distribution assumed was not reported by Westinghouse (1973).

17. Suspended particulate concentrations were - calculated by Westinghouse using the Gaussian diffusion mode, Pasquill-Gifford dispersion coefficients, and the meteorological data gathered at Colstrip by Super et al. (1973).

18. Emitted particulate may contain ferric oxide, vanadic oxide, and iron and manganese salts. The two oxides and also nitrogen oxides catalyze the oxidation of SO_2 to sulfur trioxide, while the salts catalyze the SO_2 water reaction. Other particulates may also catalyze SO_2 oxidation through adsorption processes (US Department of HEW, 1970).

19. Overcamp et al. (1971) site a reference who reports that the exit air from a cooling tower is saturated and at a temperature approximately equal to the average of the inlet and outlet water temperature.

20. Stack height 244 m. Cooling tower height 99 m.

21. In 1970, 29.5% of the population of Rosebud County was school-age (5-17). This was an increase over the figure for 1960, which was 28.5%. Nationally, elementary and secondary school enrollments have been leveling off or even declining. If this trend occurs in Rosebud County, the proportion of school age children to the total population in Rosebud County might stabilize at around 30%. This assumption, when applied to the direct population (in which 80% of the workers have an average of 2.5 dependents), leads to 1.125 school-age children per married worker.

22. Low, moderate and high estimates of the peak construction and direct permanent population at Colstrip have been developed. The "moderate" estimates have been used in this report.

If 460 construction workers were on site in August 1973, and if 670 were on site in April 1974, and, if the work force estimated by WECO as 1658 for 1978 are all construction workers, then the boom construction should be 1977-79, based on the assumption that the growth process for Units 3 and 4 is similar to 1 and 2.

If the WECO estimate of 660 is considered to be a low feasible estimate, then a 5% increase over this might be considered a moderate feasible estimate, and a 10% increase might be considered a high feasible estimate for miners, operators and service personnel.

If experience at Rock Springs, Wyoming is useful, the WECO estimates for construction workers could easily be too low. The figure of 1,658 may not be intended to apply to only construction workers. If it does not, then presumably a lower figure, perhaps 1,500, would be a feasibly low figure. 2,000 workers could be a feasibly high figure, while 1,750 construction workers could be a moderate figure.

23. See footnote 2 preceding.

24. See footnote 3 preceding.

25. See footnote 2 preceding.

26. The demand for construction personnel may also sharply drop. However, this is not considered a viable possibility unless a labor dispute should occur.

27. It appears that very few ranchers in southeastern Montana have actually sold land to coal companies or land speculators. "If you sell out, then what will you do? You will no longer have roots and you will do and be nothing." One rancher who has leased said, "We'd all want to sell to another rancher if we sell, but only to another rancher." This interviewee is revealing his reverence for the land and a commitment to keeping it productive for cattle raising. The difference between selling and leasing to coal companies is mostly symbolic, however, since in either case the land would be torn up if industrialized.

28. One company official said that most coal is not found under farmland and that the flat-lying coal seams of eastern Montana have, in most instances, been eroded away in the valleys where most farming is done.

29. However, MPC publicly announced that it would help Colstrip secure several badly needed temporary classrooms.

30. Interviewees mentioned many times that representatives of MPC lied when asking for permission to put power lines through the area. The general approach is that the company representatives tell each rancher that he, individually, is the last one to stand in the way of power line construction, but apparently the same story is told to all the ranchers.

31. It was reported that while Northern Pacific was trusted, its successor, Burlington Northern, was unable to carry on this tradition for very long. Although not universal, the present negative attitude toward Burlington Northern stems primarily from the fact that the company has acted high-handedly in putting pressure on ranchers not to complain about the activities of coal companies. Threats have been made to withdraw the leases of dissident ranchers leasing land from the railroad.

32. They could, of course, buy from and sell to fellow ranchers for less than the coal companies are offering if the sellers are committed to a ranching life-style and financially able to accept less money.

33. At least one newspaper report has suggested that overall water needs for maximum energy production might at times require as much as two-thirds of the Yellowstone River (Missoulian, October 25, 1973). Water would have to be trapped

and stored for gasification plants; most likely spring runoffs would supply the bulk of this need. Such storage would necessitate additional construction which will have an impact of its own.

34. Interviews with construction workers at Colstrip lead the researchers to point out that rootless persons, called "boomers," enjoy the novel experiences and strangeness which are part of being highly mobile and have no interest in getting involved in local organizations or affairs or in developing social ties. The rooted are at a great disadvantage in trying to deal with people for whom uncertainties and uncommittedness constitute a way of life.

The researchers' observations suggest that ranchers who see in coal an opportunity to make money suddenly begin to become estranged from the local scene in the way that boomers are. These ranchers tend to become inordinately loyal to themselves and act as though they, like boomers, are rootless and therefore not responsible for the effects of their actions on their friends and neighbors. This estrangement, temporary though it may be, can function as a way of absolving oneself from feeling responsible for doing something about the social problems one may create.

35. For example, some Rosebud County residents have observed that the companies report the evaluation of their equipment and county officials are not always able to determine its accuracy. This procedure suggests that the companies are not carrying their fair share of the tax load and do not intend to. In fact, some interviewees noted, it appears that they are deliberately seeking ways to avoid doing so. In contrast, an MPC executive stated, "We even try to report equipment on railroad cars so that we can pay more taxes to the county."

Another tax concern involves reclamation. Some feel that the cost of reclamation should be separated from rather than tied into net proceeds for tax purposes since by artificially inflating reclamation "costs", net proceeds tax can be greatly reduced.

36. Ranchers have also expressed this desire.

37. The Mormon church was cited (by a non-Mormon) as the only group making a big effort to be helpful to newcomers by welcoming them and providing activities.

38. The housing situation is further described in Section 10.2.2.2. 3a.

39. One interviewee mistakenly said that the "Water Resources Board" (predecessor of the Department, which was created in 1971), was not allocated the money needed to enforce Montana's 1973 water law and has had hundreds of applications for water under the new law but no money to publish or otherwise start to work on them. The adjudication procedures need to be carried out stream by stream, and, if they are not, this interviewee believes the moratorium may really be needed. (The adjudication of existing water - rights in the Powder River Basin is currently in progress).

40. Miners say this is not as nice a place in which to live as it was when they first came

because of the construction workers who have arrived. Miners do not want too many people around, and they do not like the kinds of people who are moving in. Because a number of miners are Mormon, non-drinkers, and heavily family and church oriented, they have little in common with construction workers who normally do not abstain or who have had to leave their families behind.

41. In Colstrip and Forsyth, a "new person" is one who has resided there for less than one and a half or two years. It takes rather longer to lose one's "new person" identity in Gillette, Wyoming, a comparable community.

42. In contrast, almost all the merchants at Ashland, a small town located in the southern part of the county, are (or were) ranchers and have opposed development from the start.

43. Living in a temporary trailer area may tend to make strong family ties stronger and weak ones weaker.

44. The enrollment is expected to go from less than 300 students as of last year to 1,800 in the near future, when construction activity is at its peak (see Billings Gazette, March 17, 1974).

45. A public meeting concerning industrial revenue bonds was held in Forsyth on March 21, 1974, and the President of MPC took the occasion to announce that his company would assist the school district in providing several additional temporary classrooms needed to avoid split shifts. One company official interviewed believes that the company will provide eight classrooms, an administration office, and lavatories, all in one building. This building will connect with classrooms recently constructed and will be a part of the school for as long as is needed.

46. A group of high school students is planning a Big Brother-Big Sister program for next year to help newcomers. One person in this group, himself a newcomer, stated that he tried to meet the new students because he felt he had something in common with them: "I'v moved around all my life."

47. State school figures indicate that enrollment increased by 26% in Colstrip and 12% in Forsyth in the past year. The teaching staff in Colstrip has doubled (from thirteen to twenty-six) during this same period of time, and twenty-two more teachers are expected this fall. The overall percentage increase in school enrollment for Rosebud County was 12%. According to the school personnel interviewed, the additional enrollment is not adequately financed, and its impacts will be more noticeable as population increases.

48. Colstrip does not share the teacher shortage. It was reported that the school offers a high base salary and good fringe benefits (although miners and construction workers are believed to be getting substantially more) and that many teachers apply to work there.

49. Following a practice common to quite a few school systems in the state, many teachers here have been let go at the end of their third year in order to keep the average salary level down. Consequently, the turnover rate has been high, and a large percentage of the staff is composed of first-year teachers. Discipline problems were

also reported in Colstrip and were observed to be greater with many new students.

50. Stratification at Colstrip is a self-conscious experience in which people seek to classify themselves in relation to others and to place everyone in social positions which are defined in terms of evolving characteristics as length of residence, type of job, economic status, and position on the coal development issue. Presence or absence of social roots was also reported as a major placement factor.

51. To what extent the economic hardships being experienced can be attributed to nationwide inflation as opposed to coal development is outside the scope of the present research.

52. Some fluctuations in county welfare are evident over the past few years. Most noticeable is increase in the number of households receiving food stamps.

53. Miners and others say that miners who have been in the area for one and a half to two years are viewed as old-timers, but construction workers of this same standing are still considered newcomers.

54. One interviewee reported paying over $100.00 per month last winter for the propane for his trailer.

55. The wives of workers are reportedly more sensitive to manual-nonmanual social status categories. The men work together and are not apt to make much of these categories. The women spend a good deal of time organizing and attending Tupperware and other sales parties, craft classes, and other special interest groups that do not depend on long-term social contact.

56. Various groups have formed in the face of energy development activities, and strains in the relationships of these as well as of other coal-related organizations and their members are also emerging. In spite of the difficulties, organizations such as the Northern Plains Resource Council and the Tri-County Ranchers Association have brought together people who have diverse political and environmental leanings and are helping them deal with various coal-related problems. The newly formed Rosebud Protective Association, composed mostly of ranchers, serves the area north of the Northern Cheyenne Reservation. Its members (almost 50) are interested in protecting their way of life and want a voice in the decisions and management of coal-related matters. The researchers have learned of no formal pro-development organizations of landowners and other residents in the study area.

57. Curtailed communication leads to misperceptions of the views of one's constituents. Representatives cannot be familiar with what the voters think about the coal issue if the topic is systematically avoided, interviewees remarked.

58. Support for the persons who made these observations can be found in Louise B. Young, Power over People (New York: Oxford University Press, 1973).

59. Results of the recent school board election do not support this perception. A group of newcomers at Colstrip pitted themselves against

local candidates and lost badly; apparently most of the newcomers voted for the locals, as did virtually all the long-term residents. When asked about the election, one newcomer stated, "The workers didn't want to get involved in the school election. We are not really part of Colstrip. We just work here."

60. This factionalism is apparently not simply a function of gradually emerging, opposing viewpoints. Several interviewed noted that various pro-development individuals and one company in particular were working at getting "white ranchers and Indians mad at each other," presumably in hopes of dividing or subduing any anticipated collective opposition.

61. Unpaved roads discourage tourists and cattle thieves.

62. Lack of sites for houses and trailers has been a problem in and around Colstrip. Those who are to occupy such sites desire significant input into the processes of deciding on and planning them.

63. Gemeinschaft refers to a type of social organization characterized by deeply personal, strong, primary social ties. Modern industrial societies are not considered, gemeinschaft societies, though certain social units (primarily family relationships) are strongly gemeinschaft in orientation.

64. The schools may well be a major area where newcomers will be able to develop a significant voice in local affairs. It should be instructive to follow subsequent school board and other election experiences at Colstrip and Forsyth. It seems likely that newcomers will run again soon and that one or more will be elected.

65. Some feel that the land above deep-mined coal would fall in an amount equal to the thickness of the mined seam; as such, natural stratification would be maintained. Also, deep mining is a slower process and therefore considered more desirable by some interviewees. The most undesirable feature of this method is that it would bring in even more people than are required for strip mining. However, some maintain that there should not be extensive deep mining here when the vast deposits of low-sulfur, high BTU coal in the East could be deep mined to supply the energy needs of that part of the nation.

66. A few newcomers want to earn enough money to be able to live here the way the ranchers do, and some people who came to the area as miners two or three years ago have adopted the local attitudes. These individuals, however, represent a very small portion of the newcomers. Other persons are also interested in preserving the area. In the words of one, "When Easterners buy places out here, they tend to be more resistant to industrialization than we old-timers are."

67. Most ranchers depend on leased land for grazing because they do not have enough deeded land to support their livestock.

68. Ranchers in eastern Montana are still trying to get clarification on patents concerning coal. If they had such clarification, they would not be so vulnerable to the actions of "land grabbers" (self-employed or hired people who reportedly

often use questionable methods to acquire land for coal companies).

69. The reader is reminded that the authors are speaking for their interviewees throughout this report. Authors' own comments are confined to the discussion sections except as noted otherwise.

70. Those taking an extreme position against development are considered radicals by their fellow residents.

71. "Everybody gains weight up here in Colstrip because there is nothing to do," according to one newcomer's wife and member of the local Weight Watchers group.

72. Several construction workers reported that it was widely believed among their fellows that the better workers who leave are usually replaced by people having less skill and who therefore often are unsafe working companions.

73. Labor unions have not been active in mining yet, although it has been rumored that the United Mine Workers may make their presence felt. The miners, who are heavy equipment operators, have had little, if any, experience with mine strikes and their effects.

74. The ideal typical businessman is strongly inclined to view his work much more as a means to making money than as an intrinsically rewarding and self-fulfilling activity. The ideal typical professional does just the opposite, stressing life-style much more than economics. For a discussion of this kind of distinction, see Everett C. Hughes, The Sociological Eye: Selected Papers (Chicago: Aldine-Atherton, 1971).

75. Adjusted scores based on information from the 1970 United States Census.

76. Respondents were asked to name a city, town, or county. Responses are tabulated by county.

77. Although a transportation service for the elderly does exist in Forsyth at present, care should be taken to be certain that the one individual presently providing this service is sufficient to meet existing and future needs.

78. See Grading Schedule for Municipal Fire Protection, published by The Municipal Survey Service of the Insurance Services Office, 160 Water Street, New York, NY 10038, (1973), for a more detailed treatment of the system for grading municipal fire protection organizations.

79. At present, Sheridan, Wyoming with a population of 10,900 enjoys daily airline service from Billings to Denver. However, the Sheridan airport serves a large region of Northeastern Wyoming and southeastern Montana with a total regional population exceeding 50,000. If no service were provided to Sheridan, the nearest airports providing regularly scheduled commercial airline service would be Casper and Billings. In contrast, Rosebud County residents can choose among closer airports located in Billings, Sheridan, and Miles City.

80. In the original housing survey conducted by Western Energy, condominium housing units were offered as an option to company employees. Few of the responsents expressed interest in this type

of housing at that time; however, in the meantime, the nation as a whole has experienced a great increase of public interest in condominium housing.

81. Even though a number of recreational facilities are planned or under construction at Colstrip (as noted in the preceding chapter), the total may not be sufficient to community need or sense of need. In relation to the desire for recreation facilities expressed by present construction-related Colstrip residents, the promise of future facilities is not satisfying, but at least conditions are expected to improve with time.

82. See Billings Gazette, February-August 1974, both news stories and letters to the editor.

83. See Frederick H. Bair, Jr., Regulation of Modular Housing (Chicago: American Society of Planning Officials, 1971; and Modular Housing, Including Mobile Homes: A Survey of Regulatory Practices and Planners' Opinions. (Chicago: American Society of Planning Officials, 1971).

84. One mill is equivalent to a one dollar tax per $1,000 of taxable valuation.

CHAPTER TWELVE Long Term Impact Considerations and Information Dissemination

12.1. Adverse Impacts Which Cannot be Avoided

Large power plants, such as those proposed to be built at Colstrip create a large number of impacts upon the natural and cultural environments, many of which are adverse. Chapters 9 and 11 treat those impacts which are expected to occur if Colstrip Units 3 and 4 are built as proposed. By careful design and use of adequate controls, some of the impacts described earlier in this report could be eliminated but others are inherent to the plant complex and cannot be avoided. This section treats those adverse impacts which cannot be avoided if the plant is built.

12.1.1 Aesthetic Impacts

Aesthetic values are highly personal and involve one's feeling of beauty - visual and otherwise. Although these values cannot be quantified, they are an important, driving force in human affairs and one of the aspects that make man human. To deny aesthetic values in our environment deprives us of some of that humaness (Dubos 1968).

In the minds of many people, no power plant can be visually attractive. Despite clever photographs and paintings, colorful paint on the exterior, landscaping, and the like, many persons will view the power plants at Colstrip as ugly obtrusive symbols of man's arrogance in a land of broad skies and pretty hills. Others will not share this view and for them there may not be any aesthetic impacts. Other persons will consider other kinds of aesthetics.

Less than 100 years ago, the Colstrip area was inhabited by the American Indian living a life free from any domination. Shortly thereafter the Indian was pushed aside and the white cattlemen came to dominate the land. Less than 98 years after General Custer passed within a few miles of Colstrip, huge machines were tearing up the land, a tall stack with flashing lights dominated the sky, and plans were being made to bring more changes to the land than had occurred in millennia.

These concerns are sometimes thought to be "emotional" influences which should be ignored, although emotions are considered wrong only when they get in the way of "progress". Emotions in other places and times wrought the great cathedrals of Europe, established a free nation on this continent, and clashed at the Little Bighorn 98 years ago. The aesthetic impacts must not be overlooked.

12.1.2. Land Use Impacts

Land use would be affected in several ways by the proposed plant and associated facilities which would occupy over 700 acres. Although perhaps this area could be reduced in size, a large area would still be affected. The mining of coal for the plants would disturb much more land and restrict its use. At 150 acres per year, the mine would disturb some 5,500 acres in 37 years, and this amount would increase if the plant operates longer. Even if complete reclamation is possible, several hundred acres would be out of production at any one time. The additional land use requirements for living space and recreation of plant and mine employees and their families would have an impact which cannot be avoided.

The commitment of land to industrial purpose establishes new patterns around which future land use will evolve. The location of future industrial, residential, and commercial centers will fall under the influence of these new patterns. Effective land-use planning could eliminate some of the undesirable patterns, but the influence of Units 3 and 4 would be unavoidable.

12.1.3. Pollution

Pollution is an unavoidable impact of any power plant. Abatement devices, no matter how sophisticated, cannot control all of the pollutants, and as collection efficiency rises so do costs of both plant operation and energy consumption. Meadows (1972) illustrates this fact by showing costs of reducing SO_2 and particulate pollution in a city. A 5% reduction in SO_2 and 22% reduction in particulates would cost $50,000. A 42% and 66% reduction, respectively, would cost $7.5 million, and a 48% and 69% reduction would cost $26 million.

Some particulates, SO_x, NO_x, and trace elements are unavoidably emitted into the air. Meeting air pollution standards is not the same as zero impact. For some pollutants, no standards exist because not enough study has been done to determine what concentrations would be tolerated in light of the practicality of abatement. Other standards are based upon extensive studies and are a compromise between impacts and cost of control. In an area such as eastern Montana where the pollutant concentrations in the air are much lower than permitted by the ambient air standards, the power plant could meet all pollution standards yet seriously degrade existing air quality.

Carbon dioxide, a gas given off by burning organic substances such as coal (or food in our bodies) is not considered a pollutant. Yet continued, large scale burning of fossil fuel is increasing the amount of this gas in the atmosphere (Williamson 1973). Increasing carbon dioxide concentrations could bring on a warming trend in the climate. However, because of the complexity of the meteorologic systems involved, the effects of increased carbon dioxide levels are unknown.

Water pollution due to the ash disposal ponds, mining, and the domestic wastes of increased population may also be unavoidable. However, proper design of all types of facilities could keep water pollution from some of these potential sources quite small.

12.1.4. Use of Resources

The proposed power plant would directly and indirectly consume large amounts of natural resources, many non-renewable. Use of these resources is unavoidable. Section 12.2. treats this topic in more detail.

12.1.5. Social and Economic Impacts Upon Existing Communities

The proposed Colstrip project is an increment in the industrialization of a predominantly agriculturally based region. The social and economic impacts of this process are enormous. Although it is sometimes a matter of personal pereference and values to decide which impacts are adverse, major changes in local communities, both good and bad, are unavoidable. Populations will fluctuate, more services will be required, persons having different lifestyles and values will move into the area, and changes in the number, types, and ownership of business will certainly take place. Whether the community structure eventually consists of an agricultural industrial mixture, or is entirely dominated by coal-based industry, the present lifestyles will be lost forever.

12.2. Irreversible and Irretrievable Commitment of Resources

Construction of the proposed Colstrip project would directly and indirectly commit vast quantities of resources. Except for some material that may be salvaged and recycled into other uses (such as the copper and some of the steel), most of the resources are irreversibly committed. The materials that actually make up parts of the plant constitute only a portion of the toal commitment.

12.2.1. Energy

Although the proposed project is an energy converter, energy is used in building and operating the plant. Since data are unavailable to quantify energy expenses, the topic will be created qualitatively.

Of the total energy expended in the creation of Units 3 and 4, most will be consumed in mining, processing, and manufacturing the materials that will physically make up the plant. The thousands of tons of steel, wire, pipe, concrete and other materials must be transported to the site and assembled. Transportation consumes energy, the amount depending upon the type of conveyance and distance covered. On site, energy is used to handle and assemble the various materials.

The total energy consumed is expended in many complex systems. The manufacture of Portland cement used to make the concrete structures is one of the simpler examples. Clay, limestone, and other materials are mined by power equipment using electricity and petroleum products. The raw materials are then transported to the cement plant which requires energy. In the plant, the materials are handled repeatedly in the crushing, grinding, and blending prior to firing in a kiln. The kiln uses large amounts of energy derived from coal, oil, or gas to raise the temperature of the raw materials to about 2600° to 3000° F. The product is further handled and finally shipped to the buyer. Additional energy is used in pollution control at the cement plant. The building and maintenance of the equipment in the mines and plant further add to the energy commitment of the finished Portland cement. Similar but more complex systems provide the copper, stainless steel, and other materials that go into the power plant. Construction of the Colstrip project would result from great expenditures of energy in other portions of the industrial sector of our society.

Once built, the plant would continue to depend upon energy to operate; much being derived from the plant itself. Coal mining uses electric and diesel powered equipment. At present rates, the energy to mine the coal costs 10.2¢ per ton which breaks down to 3.4¢ for electricity and 6.8¢ (.23 gallons) for fuel oil. The figure does not reflect energy costs of building the mining equipment. Auxillary power requirements of the plant are about 78 megawats per unit or about 11% of the total output. Most auxillary power is needed to operate the pollution control equipment. A question arises as to how much net energy the Colstrip project would produce in light of the requirement of more such plants in the future. Although the Colstrip project cannot replace the energy used to build it, the project would contribute to the building of future power plants if electrical generation capacity contines to grow. The building and operation of future power plants will generally rely upon lower grade mineral deposits (including fuels), many located in remote parts of the earth. The increased transportation costs and more sophisticated technology needed to utilize these deposits, and to control pollution in the conversion and manufacturing of the materials used in future power plants will increase the total energy costs of each new plant.

12.2.2. Non-Renewable Resources

The non-renewable resource costs of the Colstrip project are as complex as the energy costs. The plant itself would use some 45,000 tons of steel, 94,000 cubic yards of concrete, over 1100 miles of wire and cable, and over 100 miles of pipe plus much more material in various components. Some six million tons of coal would be needed each year to operate the plants if they are constructed. The transmission lines would require about 40,000 tons of steel for the towers, 34,000 tons of steel and aluminum for the conductors, and 600,000 insulators plus an undetermined amount of concrete and other materials. Still other materials are used in manufacturing and processing the materials that actually go into building the plant and transmission lines. Metallurgical grade coal and limestone are used in steel production. Steel is used to produce some copper. Coal, oil, and natural gas are used to provide energy in the manufacturing processes. Oil is also used to produce a variety of necessary materials including plastics. Metals and energy from fossil fuels become mining equipment that provide the metallurgical coal for steel production that goes into the Colstrip plant and transmission lines, and so on. The exact amount of non-renewable resources needed to build the Colstrip project is impossible to figure, because, when considered in total, the Colstrip project becomes an indistinguishable part of the entire industrialized system.

The use of non-renewable resources is of consequence in that as the finite supply is consumed, future use will depend upon poorer, less accessible deposits and/or reliance upon more sophisticated technology for resource recovery.

12.2.3. Timberland Agricultural Products Lost

Timber and agricultural products are renewable and land use changes, in many cases, are reversible; however, products not grown are lost and cannot be replaced. A field of wheat not harvested because of construction activity is an irreversible loss of that field's production for that year.

Loss of biological production would result from long-term land use changes at the plant site, at the mine, and along the transmission line, and short-term land use changes would result during construction of transmission lines and pipelines, and coal mining (if reclamation is successful). Pollution and electrical effects could reduce biological production in the vicinity of the plant and transmission lines.

12.3. Long-Term Considerations of the Proposed Colstrip Project

Both individually and collectively, people tend to view the world on a short-term basis.

Consideration of long-term effects of their actions plays a small role in decision-making. Similarly, people place more emphasis on local situations than upon national or global ones. Thus long-term, global implications of a particular action have the least weight in decision making (Meadows 1972).

A large power complex, such as the one proposed for Colstrip, has both long-term and national (and global) implications. Since these wider-ranging effects are different from the local, short-term connotations, some attempt must be made to evaluate the proposal to build the facilities in light of the long-term effects.

In recent decades, man has experienced rapid growth of scientific knowledge and technological innovation. The great expansion of knowledge in these areas has strongly influenced the evolution of twentieth century civilization. Although not all of this change has been detrimental to mankind, neigher has it been totally beneficial. All too often, major social, political, and economic changes have accidently (not planned) come about as a result of technological change. Mankind follows the paths of latest inventions with little thought as to where all these paths will eventually lead. Technological feasibility has become the determining factor in decision making. What can be done takes precedence over what should be done (Dubos 1970).

This type of thinking, which might be called the progress ethic, was exemplified by Eric Walker in a newspaper article during the debate over funding an American supersonic transport (1971). His thesis was that the U.S. will someday have an SST because: 1) it is technically possible, 2) the Russians already have one, and 3) "just ridiculous" environmental concerns would be overcome by the engineers. He completely ignored the basic question of whether an SST is desirable and should be developed.

12.3.1. Montana Considerations

Unlike land which can produce crops and provide a living for many generations, a power plant has a rather short life. Likewise, the coal deposit, once mined, is depleted forever. The tax base and jobs provided by the Colstrip project would be transient. Continued taxes and jobs past the life of the plant would be dependent upon other industry situated in the area and agriculture.

Persons who would fill the newly created jobs are not necessarily those living in Montana at present. Unemployment in other parts of the nation besides a desire to live in Montana (because of its uniqueness) could cause great numbers of people to immigrate to the state. Children of the immigrants of coal development may well out-number the jobs available in 30 to 50 years. Unemployment may be much higher than at present as the power plants are phased out resulting in large numbers of persons (who would now be long-time residents) being forced to leave the state.

An alternative to this scenario would necessitate continued industrial development in eastern Montana. Continued long-term industrialization to maintain employment and a tax base has even more profound effects which cannot be evaluated at this time. Pittsburgh, Pennsylvania, a heavily industrialized urban area, obtained much of its character from the rich coal deposits in the area. Although Rosebud County will probably never duplicate Pittsburgh, the two areas may share some characteristics if large scale coal development proceeds.

Although long-term effects of the Colstrip project are difficult to evaluate, we must not allow the possibilities of technology and the promise of short-term benefits to lead us unwittingly in directions that may prove to be detrimental. The implications of such decisions must be well analyzed, and the choice we make for the future of our state must be with full realizations of the consequences.

12.3.2. National and Global Considerations

Much of the world has become industrialized in the past one and a half centuries. Factories and large industrial communities have sprung up in many countries. Mechanized agriculture which requires fewer persons to feed the society and the need for more manpower in the industrial sector have caused large population shifts from rural to urban environments. With industrialization came shorter workweeks and a greater supply and variety of consumer goods and services. Better medical care and abundant food allowed the population to grow to increasingly higher levels. In providing material goods, security, and comfort, industrialization has worked very well in the United States. Based upon consumption of resources, the United States is remarkably outstanding. With only 6% of the world's population we consume about one-third of the world production of raw materials and energy (Singer 1970).

Industrialization, in the context used above, is a complex process involving all aspects of society. Social, economic, political, and technological systems have changed or grown in the process. Especially in the twentieth century, technology and highly technological systems, which have accounted for much of industrialization's success, have grown enormously.

The lifestyle enjoyed by the majority of Americans in the 1970's is one of relative security, comfort, leisure, and an abundance of material commodities. It is also one which is totally dependent for its existence upon a large number of highly complex systems. Combined in a mutually interdependent manner, these complex systems form a higher order system (supersystem) that not only provides our amenities but keeps us alive by providing our basic needs. Very few people grow their food, make their clothes, build their homes, or collect the fuel to heat those homes. Even today's farmer generally buys much of his food at a supermarket.

The supersystem feeds and grows upon itself with the help of several contributing factors: 1) increasing population, 2) growth of per capita consumption, 3) increasingly complex systems to produce the raw materials and products to sustain high populations and per capita consumption, and 4) increasingly complex systems to remedy the ill effects of the producing systems. These four factors will be analyzed separately.

The population of the world is rapidly growing. The approximately 3000 million world population in 1970 may double by year 2000 (Meadows 1972). Even in the United States where birth rates have fallen to levels that, if continued, would result in zero population growth, the population will contine to grow for several decades before leveling off. Based on estimates using the lower fertility rate (U.S. Department of Commerce 1973), the United States population will grow from 204 million in 1970 to 264 million by 2000 and 297 million by 2020.

Additional persons require more food, more housing, and more services. To double world food production would require basic changes in agriculture with resultant social and economic changes (MIT 1970). But supposing these changes could be made and such innovations as the high yield strains of grain would produce as originally expected, the increased supply of food would be inadequate within several decades if the world population continues to grow at the present rate. Increased agricultural production has been accomplished by mechanization and the increased use of energy and chemicals. This trend makes the agricultural producer more dependent upon the systems which provide his machinery, fuel, fertilizer, and other commodities. More people put more stress on the systems which provide housing, transportation, medical services, and so forth. These systems ultimately demand more energy, minerals to build additional schools, hospitals, transportation systems, and the like. As long as resources remain abundant, a growing economy can accomodate the population growth but as resources become scarce shortages and inflation occur.

An increase in per capita consumption places demands upon the producing systems just as increasing population does. Most people aspire to have more goods, services, and comfort regardless of what they already have. This aspiration makes itself felt in union halls and voting booths, resulting in business and governmental response which adds further to the growth of the supersystem.

Raw materials, especially non-renewable resources, are limited in amount. As the easy-to-get materials are consumed, more sophisticated techniques are required to obtain more.

Agricultural products, timber, and mineral resources all share this characteristic. To produce more corn, more marginal land must be farmed using special hybrid seed, more fertilizer, insect and weed killing chemicals, and energy in planting, harvesting, and transportation. To produce more oil, remote and marginal fields must be brought into production. These fields require deeper drilling, off shore drilling, or extensive transportation problems. The oil resources such as those found by observing seeps and recovered by the primitive devices available to Colonel Drake in 1859, are mostly depleted. Instead, oil is found and obtained at sea and in the Arctic by incredibly expensive techniques, using sophisticated technology, and many men and materials.

Large-scale production brings many kinds of environmental degradation, including pollution. Many industrial processes produce waste or allow materials to escape into the environment as pollutants. Processes which consume electricity, but are otherwise pollution free, merely transfer the emission of pollutants from the factory to the power plant. Since the atmosphere, land, and water of this planet are finite, pollutant levels tend to rise with greater production. To avoid severe environmental damage, technology has been applied to control pollution. In some cases, where a usable product is the pollutant, an economic saving can be realized from control, in most cases, pollution control is expensive. Sophisticated equipment and additional energy requirements increase the costs of production. Without pollution control, the costs are in the form of damage to human health and natural resources. Pollution control adds to the complexity of the producing systems and increases consumption of resources.

Many persons in our society believe that all problems can be solved by technology, and, consequently, that population and economy can grow without limit by continued application of new technology to solve the problems that arise. A glance at history serves this point of view well. For example, if we had to depend on wood for our fuel as our ancestors did, we would have frozen to death many years ago. Large power plants, ocean-going supertankers, and nuclear reactors could not be foreseen in 1840. However, technological innovations do not always work as planned, as problems with the "miracle" strains of grain, DDT, Egypt's Aswan Dam, and some modern rapid transit systems attest.

More advanced technology in a given area usually depends upon other systems which in turn require more technology. As the supersystem becomes more complex, economic and social perturbations become greater threats to the whole and each technological breakthrough becomes more essential. As the sophisticated and complex society becomes more dependent upon all of its systems, the risks involved in an incorrect political decision, economic depression, social upheaval, or war become enormous. Since personal survival is dependent on the supersystem for basic needs as well as maintenance of the lifestyle, a strong perturbation could initiate additional social, political, and military disruption which might hasten the collapse of the society. In this case, prolonged dependence upon advanced technology, if it adds to the fragility of the system, would be detrimental. The disaster initiated by the drought in the Sahel demonstrates that the reality of this kind of catastrophe is not a piece of science fiction (Wade 1974). Although the Sahelian problem was geographically isolated, a similar collapse could occur in the more advanced countries: made more likely by the strong interdependence of many countries and the threat of global nuclear war.

V.E. McKelvey illustrates part of the problem (1973):

> ...in attaining our high level of living in the United States, we have used more minerals and mineral fuels during the last 30 years than all the people of the world used previously. This enormous consumption will have to be doubled just to meet the needs of the people now living in the United States through the remainder of our lifetimes, to say nothing about the needs of succeeding generations, or the increased consumption that will take place in the lesser developed countries if they are to attain a similar level of living.

And further,

> If resource adequacy cannot be assured into the far-distant future, a major reorientation of our philosophy, goals, and way of life will be necessary. And if we do need to revert to a low resource consuming economy, we will have to begin the process as quickly as possible in order to avoid chaos and catastrophe.

If we include under "resource adequacy" the social, economic, and technological systems which convert raw resources into usable products and services, continued growth without regard for long-term dangers becomes a gamble. The Colstrip project would add to the growth of the size and complexity of the supersystem which some (Meadows 1972) feel will ultimately fall. If the prediction is true, all social, economic, and environmental impacts, except as they contribute to the demise of the system, become minuscule.

12.4. Public Involvement

12.4.1. Background

By January of 1974 substantial public comment had been generated on Colstrip-related proposals. The final EIS on Units 1 and 2 (now under construction), published by HES reported over

3,000 written responses from the public relating to the proposal. These responses came in the form of letters, postcards, coupons and signatures on petitions, and approximately 95% of the responses opposed development of the plant and coal mining operations (HES 1973).

The final EIS reported that the fears most often expressed were:

1) Strip mining would proceed with little, if any, adequate reclamation of the land.

2) Air and water would be polluted significantly.

3) Large scale water consumption would result.

4) Montana would emulate the bad characteristics of other states.

5) Present life-styles would be disrupted.

However, the EIS also reported that two major misconceptions were expressed or implied by most of the respondents. First, many people appeared to believe that all of the power from the Colstrip plant would be used outside Montana. Second, most of the responses were written "seemingly with the belief that the Air Quality Bureau (of HES) could decide to issue or deny a permit on the basis of popular opinion or criteria other than the standards established in the regulations" (HES 1973).

In the current climate of public concern, public comment of an even greater magnitude can be expected on the Colstrip Units 3 and 4 proposal. In order to process, evaluate and utilize public comment of this magnitude, as well as to dispel misconceptions that would render the comment invalid, the Energy Planning Division funded and staffed a public involvement program in June, 1974.

12.4.2. The Need for and Purpose of Public Involvement

Abraham Lincoln once said: "In this and like communities, public sentiment is everything. With public sentiment nothing can fail; without it nothing can succeed." In an era of increased public awareness, education, and communication, members of the public have come to demand an increased voice in executive political decisions. Samuel Jackson said, "The '70s will be a decade in which all segments of our society will demand an effective voice in shaping the policies that affect their lives. Citizens will be impatient with a philosophy that tells them 'father knows best' and they will demand a more active and meaningful participation in the planning process" (Jackson 1970).

An increased public voice in executive decisions will not only meet the public demand, it will also enable the agency to render better managerial decisions. If decisions are made in order to meet the values, needs and concerns of people, then public involvement can provide a means for the agency of detecting those values, needs and concerns.

Edward Cliff wrote, "A greater degree of constructive public involvement will enable us to do our job better and with greater sensitivity and responsiveness than has been possible for us to achieve in the past" (USDA 1971).

Public involvement in the planning process can provide functional communication between the planner and the public so as to most efficiently transmit pertinent information which will elicit feedback from the public on perceptions of needs and preferences (U.S. Army Corps of Engineers 1970).

Public involvement, then, can educate and inform the public on the facts surrounding the problem. More importantly, public involvement can identify public concerns. Armed with this knowledge, the decision makers can then blend public concerns into the given physical, fiscal, political and legal restraints and develop the best possible solution. Volume 4, Chapter 7, contains further information concerning opportunities for public comment on this EIS.

GLOSSARY

ADSORPTION
The adhesion of a thin layer of molecules on the surface of a solid or liquid.

AMBIENT AIR
Surrounding air.

ANTICLINE
Fold in rock where older strata lie inside, usually a fold with the convex side up.

APPROACH
The difference between the temperature of cooling water leaving the cooling tower and the wet bulb ambient air temperature.

ASSOCIATION
In the Clement's sense, a climatic climax unit that includes all of the successional stages preceding or associated with it. Plant association and animal association emphasize populations of plant and animals, respectively, within an area.

BAFFLES
Used to direct the flow of combustion gases and ensure maximum contact with the heating surface.

BENTHOS
All the plants and animals living on or closely related with the bottom of a body of water.

BIOMASS
Living weight; the total quantity per unit of space at a given time of living organisms of one or more species (species biomass), or of all the species in a community (community biomass). Cf. yield, productivity, standing crop.

BLOWDOWN
The act of draining or flushing out boiler or other water which has become too concentrated with solids or other contaminants.

CATALYST
A substance which increases the rate of a chemical reaction without being consumed in the reaction.

CLASTIC ROCKS
Sedimentary rocks consisting of fragments of older rocks or organic structures which have been transported to the site of deposition.

CLIMAX
A community capable of self-perpetuation under the prevailing climatic and edaphic conditions; the terminal stage of a sere under the prevailing conditions.

COMMERCIAL FOREST LAND
Forest land which is (a) producing, or physically capable of producing, usable crops of wood (usually sawtimber), (b) economically available now or prospectively, and (c) not withdrawn from timber utilization.

CONCRETION
Small volume of rock more thoroughly cemented than adjacent rock.

CONFORMABLE
Without an unconformity.

CONTACT
Surface separating two rock units (e.g. formations).

DBH
Diameter breast height. On standing trees, a standard height from ground level for recording diameter, girth, or basal area. In the United States, this standard height is 4 ft. 6 in. (1.37m).

DIFFUSION

Process by which gas, liquid, or solid particles are transported from a region of high concentration to a region of low concentration. On a molecular level, diffusion is due to thermal agitation. Diffusion in the atmosphere is due primarily to wind fluctuations.

DIP

Angle of inclination of tilted strata.

DISPERSION COEFFICIENT

The standard deviation of the horizontal or vertical effluent concentration in a plume.

EARTH ATMOSPHERE SYSTEM

The earth and surrounding atmosphere.

ECOSYSTEM

A community including all of its component organisms, together with the abiotic environment, forming an interacting system.

ECOTONE

A transition line or zone between two vegetation communities which has characteristics of both kinds of neighboring vegetation as well as characteristics of its own.

EUTHROPHICATION

The normally slow aging process by which a lake evolves into a bog or marsh and ultimately assumes a completely terrestrial state and disappears. During eutrophication the lake becomes so rich in nutritive compounds, especially nitrogen and phosphorus, that algae and other microscopic plant life become superabundant, thereby "choking" the lake, and causing it eventually to dry up. Eutrophication may be accelerated by many human activities.

FAULT

A fracture or zone of fractures in the earth along which movement has occurred.

FOREST LAND

Land which (a) is stocked on at least 10 percent of its surface by trees of any size, and capable of producing timber or other wood products, or of exerting an influence on the climate or on the water regime, or (b) has had the trees described in (a) removed to less than 10 percent stocking, and which has not been developed for other use.

FORMATION

A body of rock strata that have properties distinguishing them from other strata and that can be recognized as a unit.

GRASSLAND

Any land on which grasses dominate. Also, land originally dominated by grasses.

GROUP

Two or more formations considered as a unit.

HABITAT TYPE

Collective term for those areas that support or can support the same plant association, or did support it prior to its destruction or modification by fire, flood, grazing, logging. It is the physical environment of a particular association.

HEAVY METALS

Metallic elements with high molecular weights, generally toxic in low concentrations to plant and animal life. Such metals are often residual in the environment and exhibit biological accumulation. Examples are mercury, chromium, cadmium, arsenic, and lead.

HORIZONS

The individual horizontal layers of soil that appear when a downward section is cut through the soil. For convenience in study and description, the layers or horizons resulting from the soil forming processes are grouped under four headings: O, A, B, C. The O horizons are organic materials which form above the mineral soil. The A horizons are composed of mineral soils which lie at or near the surface and are characterized by a zone of maximum leaching. The B horizon is the region of

HORIZONS - Cont.

maximum accumulation of materials such as iron and aluminum oxides and silicate clays. These materials have been washed downward from the surface horizons. The C horizon is the zone of least weathering and is the accumulation zone of calcium carbonates and magnesium carbonates. Cementation occurs frequently.

INCREASER

Plant species, of the original vegetation, that increase in relative amount, at least for a time, when the community is subjected to overuse.

INVADER

Plant species that are absent in undisturbed portions of the original vegetation, and will invade under disturbance or confined overuse.

ISOTHERMAL LAYER

Layer in the atmosphere in which temperature does not change with altitude.

LATENT HEAT

The heat given off or absorbed at constant temperature when a substance changes phase (i.e. melts, freezes, evaporates, condenses, etc.).

LENS

Strata of small horizontal extent.

LIQUOR

The liquor present in the scrubbies, is a combination of the particles of combustion, water, and whatever chemicals are present. Some of these elements may be dissolved in solution and some may just be suspended.

LOAD

Total amount of constituent deposited per unit of time, commonly expressed in tons per day.

LOAD FACTOR

The ratio of the actual output for a given unit in a certain length of time to the nameplate or possible output in the same length of time.

MACROSCALE
Lengths greater than fifty kilometers and areas on the order of 1,000 square kilometers or greater.

MEMBER
A subdivision of a geologic formation.

MERCHANTABLE
(Said of trees, crops, or stands) of a size, quality, and condition suitable for marketing under given economic conditions, even if so situated as not to be immediately accessible for logging.

MESOSCALE
Length between one and fifty kilometers or areas on the order of 100 square kilometers.

MICROSCALE
Lengths less than one kilometer or areas on the order of one square kilometer.

MOLE RATIO
The ratio of the number of molecules of the constituents in a compound.

NONCOMMERCIAL FOREST
Forest land stocked by species that have no value commercially.

NONHYGROSCOPIC
Does not readily pick up and hold water.

NOXIOUS PLANTS
Undesirable plant species that are unwholesome to the range or animal. Not to be confused with species declared noxious by certain laws.

NUCLEI
Particles (dust, sea salt, etc.) in the atmosphere which promote the formation of liquid water droplets from water vapor (condensation nuclei) or of ice from liquid or gaseous water (freezing nuclei). In the absense of freezing nuclei ice would not form in the atmosphere at temperatures above -40°C.

PALATABILITY

The relish that an animal shows for a particular species, plant or plant part.

PARTICULATE MATTER

Dispersed solid or liquid matter in which the individual aggregates are larger than a single molecule (U.S. Dept. HEW 1970).

PARTICULATE SETTLING VELOCITY

The terminal rate at which particulates fall in the air. Settling velocity in still air is a furiction of particles density and shape, and air viscosity.

PERIPHYTON

Sessile algae, including diatoms, growing on the mud, rocks, logs or higher plants of the river bed.

PHYTOPLANTON

Microscopic plants which are found suspended or floating in bodies of water such as lakes and rivers.

PLANKTON

Microscopic organisms which are found suspended or floating in bodies of water such as lakes or rivers.

POISONOUS PLANTS

Plants containing or producing substances that, consumed by animals, result in sickness, death, or deviation from normal state of health.

POLE SIZE

A young tree with DBH of 5-9".

PRISTINE (or near pristine)

Used to describe areas on which there has been little or no grazing by domestic livestock, and which has been otherwise undisturbed. These areas show the kinds and amounts of vegetation that will develop naturally on a given soil and in a given climate, and provide criteria for determining the condition of the range.

QUASI-PLANKTON

Dislodged members of the periphyton community, bits of dedritus, and drifting aquatic insects or micro-organisms which are not normally planktonic in habit.

RANGE

(Chapter 8) The difference between the temperature of cooling water entering the cooling tower and the temperature of cooling water leaving the cooling tower.

RANGE CONDITION

(Section 10.1.6) The state and health of the range based on what it is naturally capable of producing.

RANGE CONDITION CLASS

One of a series of arbitrary categories used to classify range conditions, usually expressed as excellent, good, fair, or poor.

RELATIVE HUMIDITY

The ratio of the amount of water vapor contained in the air to the amount which the air could contain if saturated.

RELICT

Used to describe fragments of presently existing flora on areas with a historical record of no disturbance, where that plant community is assumed to be in near virgin condition.

ROTOR

The generator rotor is a large conducting shaft which rotates inside the stator field to produce electricity.

SALINE/SODIC-SOILS

Soils with sufficient quantities of neutral soluble salts and absorbed sodium ions to seriously affect most plants.

SAVANNA

An area of grassland in which are scattered trees or shrubs but little or no breaks in the continuity of grassland cover.

SAW TIMBER SIZE
Trees having DBH of 9" or greater.

SEDIMENT TRAPS
Devices designed to stop or slow the movement of sediment; in Montana, most commonly consisting of concrete bunkers.

SEEDLINGS AND SAPLINGS
Trees having DBH of less than 5".

SEICHE
Oscillation of a body of water with a period of several minutes to an hour or more.

SEISMIC
Pertaining to earthquakes.

SERE
The series of stages that follow one another in an ecologic succession.

SESSILE
Attached to the substrate.

SHRINK/SWELL
The characteristic of soil particles to expand or contract. When soils contract, cracks commonly appear on the surface horizon. The expanding and contracting is important to construction, especially foundations and pipelines, because it forces movement of solid objects, causing crumbling and cracking of foundations. The coefficient of linear extensibility is a measure of shrink/swell. Clay soils tend to contract and expand a lot.

SITE CLASS
A measure of the relative production capacity of a site for the crop or stand under study, based e.g. on volume or height or the maximum mean annual increment that is attained or attainable at a given age.

SITE INDEX
A particular measure of site class, based on the height of the dominant trees in a stand at an arbitrarily chosen age (see site class).

STATOR
The generator stator is the stationary outer winding which provides the strong magnetic field necessary to produce electricity.

STOCKING
A measure of the proportion of land area actually occupied by trees, expressed in percent of canopy closure.

SUBSTRATE
The medium on which an organism grows.

SUPERSATURATION
Relative humidities greater than 100%.

SYMBIOTIC
The living together of two or more different species in a mutualistic situation.

SYNCLINE
Fold in rock where younger strata lie inside, usually a fold with the convex side down.

TEMPERATURE INVERSION
Condition in the atmosphere in which temperature increases as altitude increases.

THIXOTROPIC
Capable of becoming fluid when shaken.

TILTH
The physical condition of the soil in its relationship to plant growth, considering such factors as percentage of coarse fragments, depth of bedrock, fertility, texture, etc. Usually rated as good, fair, or poor.

TRACE ELEMENTS
Micronutrients; elements necessary for the operation of living systems, but which are required only in minute quantities, often as components of vital enzymes.

TSUNAMI
Large sea wave, incorrectly called "tidal wave".

UNCONFORMITY
A furface in the earth's crust representing erosion or non-deposition.

U.S. STANDARD ATMOSPHERE
The average characteristics (e.g. pressure, temperature versus altitude) of the atmosphere at 40°N latitude.

VOLATILIZATION
The process of exposing a solid such as coal to high temperatures, eventually resulting in the production of various gases.

WET BULB TEMPERATURE
The temperatures to which air may be cooled by evaporating water into it at constant pressure until it is saturated.

WIND SECTOR ($22\frac{1}{2}^{\circ}$)
One of sixteen divisions of the total possible range of wind directions (i.e. 360°). The sixteen divisions are: N,0°; NNE, 22.5°; NE, 45°; ENE, 67.5°; E, 90°; ESE, 112.5°; SE, 135°; SSE, 157.5°; S, 180°; etc.

GEOLOGIC TIME SCALE

Era	Period	Epoch	Approximate Age in Millions of Years
Cenozoic	Quaternary	Recent	.01
		Pleistocene	2
	Tertiary	Pliocene	12
		Miocene	25
		Oligocene	40
		Eocene	60
		Paleocene	70
Mesozoic	Cretaceous		135
	Jurassic		180
	Triassic		225
Palezoic	Permian		270
	Carboniferous	Pennsylvanian	310
		Mississippian	350
	Devonian		400
	Silurian		440
	Ordovician		500
	Cambrian		600
Precambrian			to 4500

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